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Volume 20 Number 1
February/March 2015

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Unmanned Vehicles is published six times
per year – in February/March, April/May, June/
July, August/September, October/November
and December/January – by
The Shephard Press Ltd,
268 Bath Road, Slough, Berks, SL1 4DX.

Air Business Ltd is acting as mailing agent.
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© **The Shephard Press Ltd, 2015.**
ISSN 1351-3478

DTP Vivid Associates, Sutton, Surrey, UK

Print Buxton Press, Derbyshire, UK



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www.UVonline.com

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Front cover: An artist's impression of ATK's 3kg Hatchet munitions in action. (Image: ATK)

Subscriptions

Shephard's aerospace and defence publishing portfolio incorporates seven titles: *Defence Helicopter*, *Digital Battlespace*, *International Maritime & Port Security*, *Land Warfare International*, *Military Logistics International*, *Rotorhub* and *Unmanned Vehicles*.

Published bi-monthly or quarterly, each is respected and renowned for covering global issues within its respective industry sector.

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A force for good

Phew. Is anyone else amazed by the daily advances in unmanned vehicles? Barely an hour goes by without a Google alert for 'UAV' or 'drone' dropping into my inbox.

I think this will be the year that we really start to see where the niche areas are in this industry. The clever ones will be those who can spot commercial opportunities and field their technology quickly into the marketplace.

We've always known that unmanned vehicles have potential for a wide range of applications, but now that the FAA has begun granting exemptions to companies in the US to allow commercial operations in civil airspace, hopefully this will be realised by those outside of the community.

As such, this issue features a special report by Angus Batey, who has discovered that consensus around the legal issues of introducing UAVs into civil airspace does at least now seem to be forming (see p14).

The pace of legal reform is yet to catch up with the speed of potential positive applications though, such as delivering aid in disasters, monitoring the growth of crops or protecting endangered species from poachers.

These 'good news' stories have been something of a reminder that UAVs aren't only the preserve of militaries who seek to weaponise them. In this issue, I looked into some of the weapons integration programmes (see p8) currently under way. It's an exciting area with some incredible engineering, but it's also very difficult to extract the fine detail due to its sensitivity.

After writing the article, to remind myself that it's not all about combat, I looked into some of the life-changing ways UAVs are planned to be used to deliver small packages, another potential growth area.

Having said this, I make no apology for having an artist's impression of ATK's latest munition, Hatchet, on the front cover of this issue. It is a 3kg bomb that packs a punch and could end up on both manned aircraft and unmanned platforms in the future. It is hoped that small 'precision munitions' like Hatchet may go some way to minimise the collateral damage that drone strikes receive so much bad press for.

Indeed, this kind of coverage continues to feature in the mainstream media. On 21 January, the BBC News website published a video entitled 'The drone operator who said "No"'. It features a former US operator, Brandon Bryant, who says he felt increasingly uneasy with what he was doing. 'We saw shadows of people and we killed those shadows,' he states in the video. There's even a film due out in April, called *Good Kill*, addressing similar themes.

While the US has had its unmanned strike capability for some time, we find out in this issue how China is developing UAVs for the same purpose. Gordon Arthur's feature (see p31) follows on from one we published in the magazine exactly a year ago. Back then, we asked whether the country would become the next dominant player in UAV technology – and this now seems to be the case.

Elsewhere, Claire Apthorp looks at the trends in VTOL designs (see p23), finding that it is the maritime arena that is brimming with developments.

There is also an exciting growth in small 'cargo carriers', an area that Scott R Gourley has investigated in more detail (see p43). With platforms like CaMEL, MUTT and Husky, there is plenty of scope for more animal-based names where they came from... Send your suggestions to me and I'll tweet the best.

Daniel Tye, Editor

RESPONSE

Unmanned Vehicles' editorial team is always happy to receive comments on its articles and to hear readers' views on the issues raised in the magazine. Contact details can be found on p1.

IN THE NEXT ISSUE

- Mine clearance
- Propulsion
- Quadrotors
- EO/IR payloads

Sky-Futures set to enhance UAS training in the UK



Photos: Sky-Futures



UK company Sky-Futures has unveiled an enhanced UAS training programme after being awarded National Qualified Entity (NQE) status from the UK CAA.

The NQE status – only the third of its type in the country – means the company can now train its own operators and help others gain ‘permission’ status to operate SUAS in the UK.

Sky-Futures has held its permission to operate UAS for the past four years. The team has amassed 8,500 hours of flying experience with UAS in the military and on inspection tasks for oil and gas clients.

The NQE allows the company to train remote pilots to so-called Sky-Futures remote pilot (S-FRP) status against their CAA approval.

‘We’ve built up our training capacity as we’ve grown,’ Nick Rogers, training and legislation director at the company, told *Unmanned Vehicles*. ‘We went from five to 20 people last year and now have eight remote pilots – but that is likely to treble this coming year.’

Describing what would-be UAS remote pilots will have to go through, he said: ‘They’ll do two days of ground school before starting initial and advanced flying training. They will fly 64 sorties in total, with each flight lasting about ten to 15 minutes. We expect initial training to last about five days and then three days for the advanced.’

The two days of ground school deals with teaching the uninitiated about airspace and the rules around safe UAS operations.

Initial flight training is then carried out on the Finch UAS, which doesn’t have a payload and costs a lot less than the AscTec Falcon 8 system that Sky-Futures operates commercially.

Rogers added: ‘It’s just like what you’d do on a manned private pilot course, as trainees would always start on something like a Cessna 152, so the Finch is the UAS equivalent of that.’

In advanced training, the pilots will have to show they can safely operate the UAS when some of the guidance and height-holding systems fail.

‘What we really need people to do is when the systems start behaving strangely is to be able to recover it in manual mode, ie raw data, using those radio-controlled skills that perhaps they have or haven’t got before they come to us,’ he noted.

Once they’ve proven their skills in advanced training, they can then move onto type training for the Falcon 8, which takes from six to eight days ‘depending on how they are doing’.

While there are only two other companies that hold a CAA NQE status (Resource Group UAS and EuroUSC), Rogers said Sky-Futures

will use its slightly differently. ‘Our training is not aimed at guys who are going to do things like real estate – it’s more for the levels above that,’ he explained.

‘Our course takes it a step further as the requirements to work safely in industries like utilities and oil and gas mean that you need to be much more proficient.’

Asked if Sky-Futures will carry out type training for companies that bring their own UAS, Rogers responded positively: ‘We haven’t had that conversation just yet, although we’ve had enquiries.’

‘The first thing that I would need to see is an operations manual, which I’m prepared to help them with, and then we can look at the specific area of commercial UAS work they are intending to venture into.’

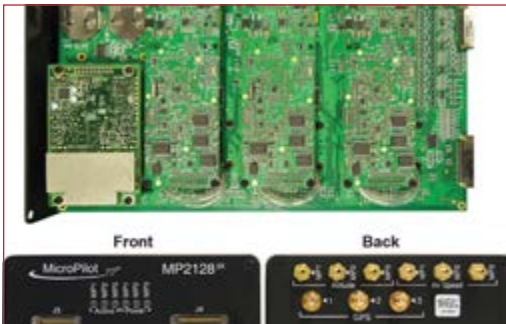
‘Our excellent remote pilot instructor experience and the generic training package is designed to suit other UAS types, provided the system is both safe and fit for purpose for the flying intended.’

Rogers was keen to point out how proactive the CAA has been and how its philosophy of ‘keep it simple, keep it safe’ is helping the industry begin to flourish. ‘At the commercial level, there’s now a whole raft of operators and that’s only been possible thanks to the UK CAA’s light touch approach,’ he said.

‘Having said that, they did a very thorough audit on us and they make you work hard for it. But because of the regulation and enhanced safety aspects in oil and gas, we’ve had to go that step further.’

By Daniel Tye, London

Are partnerships the way forward for the industry?



A number of UAS companies have announced partnerships in the past month, in what could be a sign of things to come in the industry.

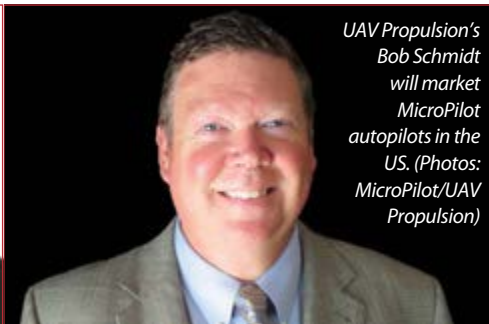
UAV Propulsion will help MicroPilot market its family of autopilots in the US, while PrecisionHawk has partnered with an investment company, Measure, so it can engage with a global clientele.

Bob Schmidt, founder and president of UAV Propulsion said the addition of MicroPilot's autopilot line, particularly the triple redundant solution, will expand his US UAV product offerings and added: 'It will allow us to provide solutions that will improve the performance, functionality and reliability of UAVs. I want UAV Propulsion Tech to become the place that defence and commercial UAV developers can come to for the most advanced propulsion, servo, autopilot and parachute solutions.'

In the case of PrecisionHawk, it says Measure will be able to assist in its business. Together, they can provide better guidance and support. PrecisionHawk CEO Christopher Dean said: 'In partnering with Measure, we can collectively engage with global clientele in an advisory and operational capacity to ensure users see a return on their investment.'

Meanwhile, Brandon Torres Declet, CEO and co-founder of Measure, said: 'PrecisionHawk's analytical software, among the most sophisticated in the world, is a critical tool for clients who need powerful near-real-time data processing capabilities.'

'As a Measure partner, we plan on integrating the DataMapper software solution with select clients through our drone as a service offering.'



UAV Propulsion's Bob Schmidt will market MicroPilot autopilots in the US. (Photos: MicroPilot/UAV Propulsion)

Meanwhile, a spike in demand for gyro-stabilised gimbals has forced UAV Vision to build another production centre in Sydney, adding to the Australian company's existing production premises in Port Macquarie.

The company says the new centre will allow it to work 'a faster rate than was previously possible'. The CM100 and CM160 are the firm's flagship products. The CM100 is a lightweight (0.8kg) gyro-stabilised gimbal suitable for UAV platforms, while the slightly heavier (1.5kg) CM160 is suited for both manned and unmanned aircraft.

A spokesperson told *Unmanned Vehicles*: 'We are manufacturing the CM100 at our new facility in Sydney as it is our most popular gimbal and, with current demand at a high level, we needed the extra facility to accommodate the spike in demand.'

UAV Vision has a new gimbal too, called the CM100 V3, which contains a Hitachi DI-SC120R EO sensor giving users 30x zoom and enhanced stability at full zoom. The spokesperson noted that '2014 was a watershed moment for UAV Vision'.

The company's main markets include Australia, western Europe and the US.

'We've had clients use our products for shark spotting, feral animal culling, pipeline inspection, border patrol and intelligence-gathering to name a few,' the spokesman added.

Expect to see and hear about more of these kind of partnerships and production improvements as the year progresses.

By Daniel Tye, London

On the web

Raytheon acquires Sensintel
30 January 2015

Fire-fighting mission goes unmanned
22 January 2015

IE-Pacific wins Triton contract
22 January 2015

New RPAS regulations go live
21 January 2015

Japan selects Hawkeye and Global Hawk aircraft
20 January 2015

Formation of Pterosaur UAVs soars in China
16 January 2015

MQ-9 Reaper clocks record-high flight hours
15 January 2015

Global Hawk flies record mission hours
9 January 2015

More UAS exemptions on the way, says FAA
9 January 2015



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Boeing's SHARC swims

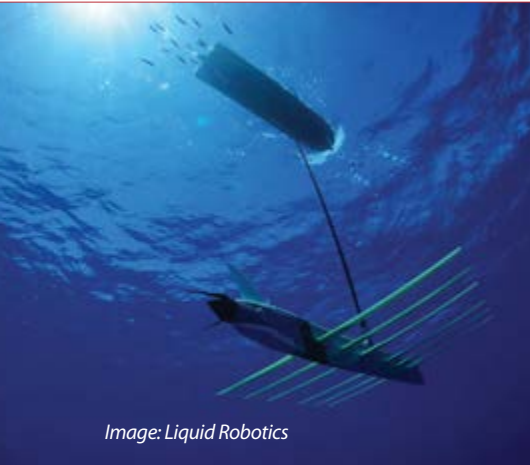


Image: Liquid Robotics

Boeing's Sensor Hosting Autonomous Remote Craft (SHARC) has swum off the coast of Hawaii. The demonstration took place in Kamuela, near Liquid Robotics' engineering, test and evaluation centre.

SHARCs will eventually be used for data collection, surveillance and acoustic monitoring. Just as sharks swim in shoals, SHARC will also do this, being able to talk to other systems as well as data centres and other Boeing UAVs. Engineers claim it will be able to stay at sea for a year with just small amount of servicing, mostly involving removing barnacles from its sensors...

By Daniel Tye, London

Rapsody project commences

A two-year project is under way using Tekever's AR5 Life Ray Evolution tactical UAV for maritime surveillance. The programme, called Rapsody, has the support of the European Space Agency and European Maritime Safety Agency.

The AR5 Life Ray Evolution will be flown in two scenarios: search and rescue; and monitoring pollution and oil spills.

Bond Air Services will operate the UAVs, while Tekever will manage and adapt the sensor platform. DSI Information Technik will oversee security for the sensor data transmission.

By Daniel Tye, London

Creating new references in robotics

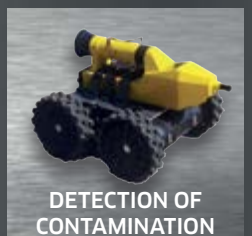
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Husky UGV maps out mines

Husky, a new UGV from the University of Chile's Department of Electrical Engineering and the Advanced Mining Technology Center, is being sent into Chilean mines to surface profile and map out areas of interest. The overall mission is to minimise manpower in the country's dangerous mines.

Husky has an Acumine 2D scanning millimetre-wave radar and a 3D Riegle scanning laser rangefinder on board, something Martin Adams, professor at the University of Chile, says will 'contribute significantly to the success and efficiency in which future mining operations take place'.

By Daniel Tye, London

Hydrogen-powered UAS achieves 80-minute flight

The Korea Institute of Materials Science (KIMS) has flown a hydrogen cell-powered UAV for 80 minutes.

The platform, White Condor, uses a polymer electrolyte membrane fuel cell developed by Cheol-nam Yang, a senior researcher at the KIMS.

He has been researching fuel cells for the past 15 years, and their use in UAVs for the past four, with his work funded by the local government in Kyeongnam.

The institute is now aiming to fly White Condor for four hours in the first half of 2015 and eventually ten hours, with the ultimate goal of a commercialised hydrogen-cell powered UAV.

White Condor is 2.5m long and 6m wide, weighs 28kg and is made from fibre-reinforced plastic. However, Yang said its



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weight is still too high and the next version will be 5kg lighter.

When asked if the 80-minute flight at an altitude of 400ft has been his biggest

breakthrough, he answered: 'No, I want to apply a more compact fuel cell system for use as a UAV power source in the future.'

By Daniel Tye, London

Mounting up

While armed forces continue air strikes from proven UAV platforms, opportunities are being created for weapons integration on emerging and more compact designs. **Daniel Tye** provides an overview.

There's a 'drone' film coming out in April called *Good Kill*, starring actor Ethan Hawke. The premise is that his character, Tom Egan, is a former F-16 pilot turned UAV operator who becomes increasingly uncomfortable carrying out air strikes without ever placing himself at risk. To quote from the trailer: 'Every day I feel like a coward taking pot-shots at somebody halfway around the world.'

OK, so it's a just film and unless you're involved in unmanned operations, you'll never know just how accurate a representation the movie is, but it does address the issues surrounding the use of UAVs to drop ordnance onto targets.

To date, such missions have been mainly carried out by MQ-9 Reapers and MQ-1 Predators armed with underwing 50kg Hellfire missiles or 220kg Joint Direct Attack Munitions (JDAMs). The new 49kg Dual Mode Brimstone has also been fired from an MQ-9 Reaper (by the UK RAF) and is just starting to be used operationally – as highlighted by manufacturer MBDA in recent advertising material, stating it is 'destroying ISIL targets in Iraq' and has been 'successfully integrated on MQ-9 Reaper'.

SIZE REQUIREMENTS

However, a number of companies working in this area have told *Unmanned Vehicles* that there are now new requirements for lighter munitions to be carried by smaller UAVs – and industry appears to be responding.

As expected, it's a sensitive area, and trying to get firm details from manufacturers about exactly what they are working on has been a challenge. Many say they are developing munitions for all aerial platforms and are

reluctant to talk about UAV-specific weapons integration. So what can we expect in the near future?

The answer is a selection of precision munitions weighing from 20kg down to just 5kg – some ten times lighter than Hellfire or Brimstone. Lockheed Martin, Hellfire manufacturer, said that it is continuing work on a 5kg gliding bomb called the Shadow Hawk PGM, which it intends to integrate on its own Shadow UAS.

The Shadow Hawk programme is internally funded, but the company has worked with the US Army Aviation and Missile Research Development and Engineering Center's (AMRDEC's) Aviation Multi-Platform Munition programme to conduct tests.

A company spokesperson told *UV*: 'The munition was released at 5,100ft and glided successfully to the target, which was illuminated by a laser spotter on the ground. Shadow Hawk impacted the target only 8in from where the laser was illuminating. That type of accuracy ensures a target can be eliminated with a greatly reduced risk of collateral damage.'

Lockheed Martin says it is continuing to work towards further testing to demonstrate

additional capabilities. 'This includes ground testing of the warhead and preparation for additional flight tests,' the spokesperson added.

MAKING PROGRESS

Meanwhile, Raytheon is making good progress with a 20kg munition called Griffin, which is being eyed for integration on Reaper/Predator. It is also working on a 6kg bomb called Pyros that uses dual-GPS/INS and semi-active laser guidance. It has three warhead options: height of burst; point of impact; or fuse-delay detonation.

Another 'light' munition is Viper Strike, a 19kg gliding bomb developed by Northrop Grumman and now MBDA, to mount on the MQ-5 Hunter UAV. The latest version is called the Viper-E, designed to hit fast-moving targets, such as vehicles. MBDA is also developing a weapon called SABER, which is specific to small- and medium-sized UAVs, coming in weights of 4.5-13.5kg depending on customer requirements. There is currently no news on which UAV platforms the company is eyeing for SABER integration.

MBDA has also been developing a UAV concept called Vigilus, an airship-like platform that loiters within an area of interest to maintain a 'vigilant watch'. It can then drop gliding weapons – either a 7kg Gladius gliding bomb/UAV with a 30km range or a 100kg Caelus gliding bomb/UAV – called down by a soldier on the ground.

MBDA has come up with an interesting animation on YouTube showing Vigilus in action. The concept is that everything is controlled from a touchscreen tablet –

'Hatchet's lethality has been around four to six times that of existing munitions the same size.'

General Atomics contractors off-load an AGM-114 Hellfire missile from an MQ-9 Reaper after a mission in Afghanistan. (Photo: USAF)



the soldier can even watch live battle damage assessment to see whether the precision UAV strike has worked out.

WEAPONISATION EFFORTS

Elsewhere, Northrop Grumman has confirmed that its unmanned Bell 407 helicopter, the MQ-8C Fire Scout, will be weaponised later this year. It will use BAE Systems' Advanced Precision Kill Weapon System that turns unguided rockets into laser-guided ones.

There have been rumours that the UK MoD was interested in weaponising the Watchkeeper WK450 UAV, but when this was put to Thales, a spokesperson explained that this is not the case, adding: 'Watchkeeper is not armed and there is no current requirement to arm it. It is used for ISR only. Our view is that the decision to arm a UAV is taken by the government or military, not by industry.'

Another popular UAV that could potentially carry a lighter munition is Insitu's ScanEagle, but the company told *UV* that it has no plans to weaponise it. 'We currently have no customer requirements to expand our UAV payloads beyond their current role and we are not

actively integrating weapons onto unmanned vehicles at this time'.

UV tried another route with Boeing, this time talking to the Weapons & Missile Systems division. However, a spokesperson also explained that the company is 'not actively integrating any of its current weapons onto UAVs', although noting that it 'stands ready to respond to future US government requirements for weaponisation of any platform'.

HATCHET JOB

Out of the new breed of lightweight munitions, one of the more exciting developments is ATK's Hatchet, a 3kg miniature bomb that the company says is 'swiftly being developed' in response to customer requests. It is a precision weapon too – laser- or GPS-guided. A spokesperson closely involved with the design told *UV*: 'It has what we call compressed carriage and is designed to go on just about any platform out there that flies.'

While ATK has also made a 10kg Hammer munition, the Hatchet is expected to make a significant impact in the market. The company states that the main design challenge has

been miniaturising the laser and GPS guidance systems for such a small unit.

'If you imagine, all the hardware that's in a laser-guided weapon, similar to what's in a Paveway or JDAM, has to go in, so all of that guidance has to be miniaturised,' explained a member of the engineering team. 'This means everything from actuators to the electronic components. That's been the most challenging aspect of designing the Hatchet.'

Another design challenge has been maintaining lethality in such a small unit. This is where ATK has used its previous experience in designing warheads. It has not used any different materials from normal, but rather it has come up with a fresh design for the munition. The company also notes that rapid prototyping and 3D printing machines have helped accelerate the weapon's development.

In live firings, Hatchet's lethality has been around four to six times that of existing weapons of the same size, and ATK's spokesperson had a succinct, and slightly amusing, way of summing this up: 'We're not just dropping a hand grenade.'

A second spokesperson within the company added that this level of lethality to weight is ➤

the unique aspect of the munition. 'The package we're delivering allows us to box well above our weight class,' he said. 'It means the Hatchet can be integrated on any kind of launch system.'

This is a boon for military customers, who no longer want the expense of firing a Hellfire, but need reassurance that they can deliver a weapon providing a similar degree of lethality.

CARRY ON

Making new munitions is one thing, but they are of little use unless they can be successfully mounted on the UAV. One of the largest producers of carriage and release technology is Exelis, the company behind the BRU-71/A pneumatic release system housed on the MQ-9 Reaper.

Exelis also produces pyrotechnically and pneumatically actuated systems. The company told *UV* that development work is now being carried out on electronically actuated systems for application to future platforms and stores.

Keith Sneddon, chief engineer at Exelis Electronic Systems based in Amityville, New York, explained some of the design challenges he faces creating bomb racks for UAVs.

'Most of the store-equipped UAVs that are fielded or emerging are designed to loiter at very high altitude at relatively low speeds and as such are exposed to extremely low temperatures,' he said. 'In addition, the time-on-station requirements and inherently low manoeuvre loads associated with these aircraft both enable and require very aggressive weight reduction.'

Sneddon's recent work has been on the electrical release of weapons, and he says the designs he has come up with have been very

'Exelis has recently been working on designing munition carriage systems that have electrical release.'



A visual illustrating the concept of ATK's precision 3kg Hatchet munition. (Image: ATK)

successful. 'These racks are well suited to UAVs because the low velocity of the aircraft enables a safe release by gravity only,' he continued. 'This differs from a more agile aircraft, where the aerodynamic forces on the store create the potential for an unsafe release with only gravity, and so require ejection forces.'

RESPONSE TO REQUIREMENTS

Maureen Koerwer, director of business development at Exelis Electronic Systems, said that overall the number and variety of rack/launcher requirements for unmanned systems is increasing. 'We have over a thousand racks on contract for the MQ-9, our BRU-71/A pneumatic rack,' she told *UV*. 'We are currently developing a twin-store capability for that platform, which will allow the Reaper to carry twice the mission payload currently possible.'

She added that Exelis is in the midst of 'extensive work' to integrate its technology with Small Diameter Bomb (SDB) 1 and 2, or GBU-39 and GBU-53: 'We're working with the primes on these programmes [Boeing and Raytheon, respectively] to perform a live-fire demo in February.'

The big news from Exelis, however, is that it has a facility in Brighton, England, where it is designing and producing small, lightweight racks for the carriage of small and micro-munitions on US and other allies' unmanned platforms worldwide. She also confirmed

the company is working with the prime contractors on the USN's Unmanned Carrier-Launched Airborne Surveillance And Strike (UCLASS) programme.

Another interesting branch of work being performed by the company is in the carriage of EW systems, technology such as secure, jam-resistant antennas for navigation and communication. According to Koerwer, the reason for this is straightforward. 'Our goal is to ensure our unmanned systems remain ahead of the threats they face and capable of outpacing emerging systems,' she stated.

CHINESE POWER

Elsewhere, China is now the world's fourth-largest exporter of arms, having overtaken France in 2014, according to data from the Stockholm International Peace Research Institute, with UAVs, particularly weaponised ones, looking to become a strong export seller for the country.

Arms control treaties limit General Atomics' export of Predator/Reaper systems, which is why nations such as China are trying to domestically develop their own armed UAV solutions. According to a US DoD 2014 report on the Asian country's military development, four Chinese UAVs are designed to carry weapons: the Xianglong (Soaring Dragon); Wing Loong (Pterodactyl); Sky Saber; and the Lijian; which is China's first stealthy UAV. ➤



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The Chinese Wing Loong on display at Airshow China in 2014. (Photo: Gordon Arthur)

The nations currently purchasing Chinese UAVs are either the country's traditional allies or oil exporters in the Middle East. While China is likely to spend \$15.8 billion on procuring UAS over the next ten years, the business of producing its own and selling them on will be even bigger business.

In the past, the Chinese military did not want the best technology exported to foreign powers, but this meant the domestic arms industry could only offer inferior designs, and so missed out on the trade. This is now changing however, and a willingness by China to sell advanced products, as highlighted at Airshow China in November 2014 (see p31), have led to an increase in exports.

So how is China progressing with weapons integration? First is the CH-4 UAV. The People's Liberation Army Air Force has been seen using the platform on state media to fire a missile at a simulated enemy vehicle. According to other online reports, the head of the project, Li Pingkun, states that the CH-4 can hit targets with a margin of error of less than 1.5m, but didn't provide details on how it guided the munitions. The CH-4 has four hardpoints capable of carrying two AR-1 laser-guided missiles and two FT-5 small guided bombs.

The weaponised CH-4 is designated the CH-4B, but because it carries stores, it has a shorter 14-hour endurance (compared to the original's 30 hours) and a 1,600km range

(compared to 3,500km). Algeria has reportedly tested the CH-4 and Pakistan is already operating the CH-3, but there's no indication that the countries are looking at integrating weapons on them.

STRIKES BY FORMATION?

While the CH-4 is clearly progressing with weapons carriage, another contender is the Wing Long UAV produced Chengdu Aircraft Industry Corporation (CAC). In January, the company flew a four-ship formation of the vehicles and reports suggest it has already sold a batch of them to the UAE equipped with BA-7 laser-guided missiles designed by the China North Industries Corporation.

The ASN-209 UAV is another Chinese platform that has undergone weapons integration. This 'G' variant can only cruise for half the time of the original, but can carry two laser-guided missiles. Egypt is currently the only known foreign user of the aircraft.

While there are fears that China will use these armed UAVs itself, it is more likely that they are under development to simply make a profit through sales to other nations that *do* want the ability to carry out strikes. In many cases, this may be operations against extremist groups threatening the security in their own country, and necessarily attacks on other armed forces.

Elsewhere, following the recent announcement that South Korea is acquiring



In January, Exelis received a follow-on contract valued at more than \$27 million to continue producing and supplying the BRU-71/A ejector rack for the Predator B/MQ-9 Reaper (619 of them).

(Photo: Exelis)

four Global Hawks via FMS and looking to develop an armed UAV capability, however details remain scarce.

Iran is another on the list that is keen to integrate munitions on UAVs. Recent developments have centred on the country's 'suicide drone' or 'kamikaze drone', the Ra'ad 85. At the end of December, a flurry of reports appeared online stating that the platform had been tested during a week-long joint military exercise between Iran's army, navy and air force.

According to an interview with an engineer on the programme, carried out by the Fars News Agency, this 'Sarallah' drone weighs just 4kg and has a low IR signature, meaning that missiles cannot lock on. It's also able to land should it face any problems during the flight, but is limited to a one-hour endurance at 86kt. The Iranians are also claiming its Shahed 129 UAV can carry up to eight missiles, but to date none have been seen to do so.

In January, a Chinese CH-3 drone was found crashed in Nigeria. Photos shared on Twitter showed it was carrying weapons.

BREAKING POINT

Militaries around the world are clearly looking more closely at the weaponisation of UAVs. Koerwer noted: 'This trend should not come as a surprise to anyone. The key issue here is what appears to be the inevitable proliferation of weaponised drones. A report from RAND claims that, so far, around two dozen countries already have armed UAV programmes at various stages of development, and as time passes, this number is likely to grow.'

While the number of weaponised UAVs to date has been limited to a couple of platforms using a handful of munition types, this is changing and changing quite rapidly. Lighter munitions and new carriage systems are starting to make it a lot easier for engineers to do more worthwhile (and clever) integration work in this area.

Meanwhile, the issues around making a 'good kill' remain. UAV operators sitting in one part of the world then carrying out strikes before going back home to their families isn't

just a clever plot for a Hollywood movie – it's actually taking place. It also appears to be getting more common.

Earlier in January, reports came out that the US UAV fleet was at breaking point. An internal memo was leaked suggesting that too many

missions and, more importantly, too few pilots, was threatening the 'readiness and combat capability' of the country's unmanned air force.

The weapons integration might be working, but will there be enough operators willing to carry out the weapon release? **uv**

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Consensus forms

Efforts to integrate unmanned vehicles into civil airspace continue to gain pace. **Angus Batey** looks at how progress is being made on the technical challenges and discovers agreement is beginning to emerge on how to tackle the legal issues.

Consensus appears to be forming about the means by which internationally complementary regulations might best be drafted. (Photo: iStockPhoto/Kontrast-FotoDesign)



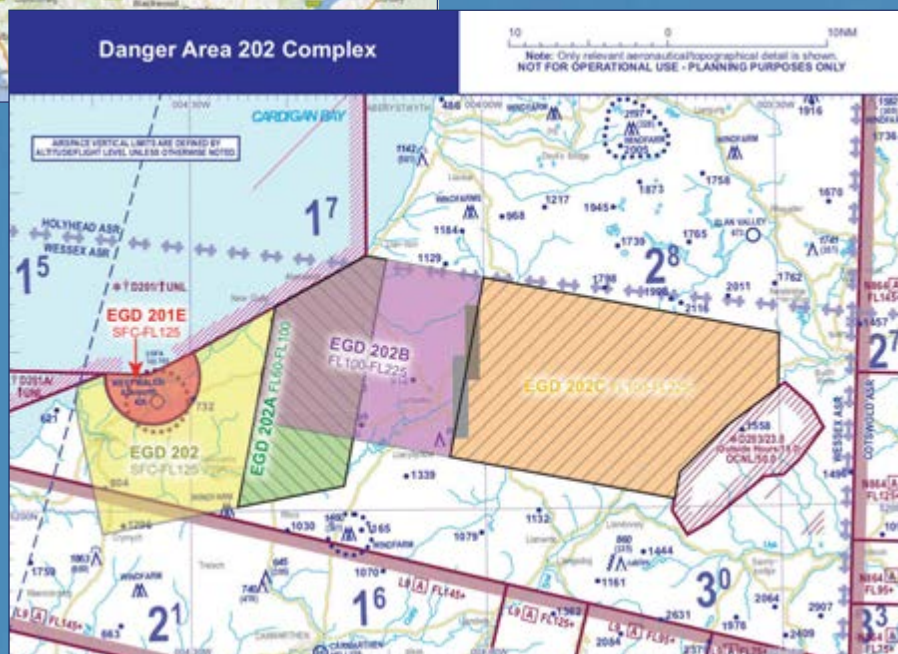
Discussing how unmanned aircraft can and could operate in civil airspace is, at times, a dogfight between airspace regulators. Many want to protect the status quo, while manufacturers and operators of UAS are anxious to free their industry from the

restrictive yoke of regulations that they consider were originally drafted for a different era. The truth is far more complicated than this.

'There are technology issues, but there are also other challenges,' Eric Sivel told *Unmanned Vehicles*. Sivel is the innovation and research



Maps showing where Aberporth Airport (left) and Danger Area 202 (below) are located. Here, UAVs can be flown from sea level to 12,500ft and then in blocks of airspace stretching across Wales up to 22,500ft. (Images: Google Maps/UK CAA Crown Copyright)



programme manager of the EASA's Safety, Intelligence and Performance department and chairman of Joint Authorities for Rulemaking on Unmanned Systems (JARUS), the multinational body trying to develop recommendations that national airspace authorities can turn into laws.

'But that's only to get into controlled airspace,' he continued. 'The biggest challenge is going to be operating them in unsegregated, uncontrolled airspace – and we are only at the start of addressing that challenge.'

PIECEMEAL PROGRESS

A plethora of initiatives – national and international, private and public, military and civil – have been under way for years, many involving the same cast of experts in an unending round of meetings, conferences and symposia. Considerable amounts of time, money and expertise have been devoted to the task so far, but concrete progress is happening piecemeal and only at national level, with different countries' airspace regulators adopting contrasting tactics in response to the demands of would-be UAS operators in each individual territory.

The US tends to dominate discussion and coverage of all issues pertaining to UAS. The Federal Aviation Authority's (FAA's) failure to meet Congress's deadline of integrating UAS into national airspace by 2015 has been a big story. Similarly, the granting of a small number of authorisations to domestic UAS operators has attracted more attention than the greater numbers of commercial UAS permits that have already been approved in other countries.

The FAA has so far issued 14 certificates of authorisation (COAs) to 13 different companies

(one holds two authorisations), which permit them to fly unmanned aircraft for various commercial purposes under regulations that were made originally to allow flights of experimental aircraft. These certificates waive certain regulations, such as one mandating that an aircraft carrying out aerial work be piloted by a qualified commercial pilot (as opposed to a private pilot) or another that the word 'experimental' be prominently displayed in two-inch-high letters above the aircraft cabin door – you can't really do this on a small UAV.

FILM INDUSTRY

The first certificate was issued on 27 May 2014 to Astraeus Aerial for the purpose of 'scripted, closed-set filming for the motion picture and television industry'. This was followed on 25 September by another six certificates, to six further companies, all for the same purpose. Perhaps not coincidentally, all these applications were made by the same lawyer and consultant who had worked with Astraeus,

implying that their involvement in the first exemption had given them a head start in understanding how to make the process work.

On 10 December, four companies were granted five certificates for precision aerial surveys, safety monitoring of construction sites and flare-stack inspections on 14 offshore platforms in the Gulf of Mexico. Later, on 6 January 2015, two more certificates were issued, one to a company wishing to carry out photogrammetry and crop scouting for agricultural clients and the other to a real-estate agent in Arizona to, in the words of the certificate, 'conduct aerial videography and cinematography to enhance academic community awareness for those individuals and companies unfamiliar with the geographical layout of the metro Tucson area and augment real-estate listing videos'.

By contrast, Australia's Civil Aviation Safety Authority (CASA) has issued approvals to 'around 180 operators', according to spokesperson Peter Gibson. 'They need to apply per flight,' he told ➤



Watchkeeper may make history this spring when it makes the first BLOS flight by a UAS in UK civil airspace. (Photo: Thales)

UV. There may be some possibility of a blanket licence to cover more than one flight, but in general each flight needs to be approved separately.'

In the UK, the Civil Aviation Authority (CAA) had issued 422 active permissions to commercial operators of small UAS as of 9 December 2014, although those licences can, and often do, cover an operator for multiple flights during a particular period of time – usually a year.

■ SAFETY FIRST

Gerry Corbett, the authority's subject-matter expert on UAS and the editor of Civil Aviation Publication 722 (CAP 722), the British regulatory framework governing commercial UAS operations, insists that the basic concept is simple. They have to be safe to fly, and flown safely,' he said.

In both the UK and Australia, the permissions so far issued have been for small aircraft operating within visual line of sight of a pilot on the ground. The FAA exemptions all apply to similar types of small quad- or octo-copter aircraft. Restrictions on operations vary, but the UK's limits – 400ft maximum altitude; 500m maximum horizontal distance from the operator; no operation within 150m of any congested area or gatherings of more than 1,000 people; not directly overhead or within 50m of any people who are not 'under the control of' the person operating the aircraft – are not unusual.

Despite the pace of developing regulations for small UAS, the challenges around flying larger systems are proving more difficult to solve. For starters, it remains unclear whether there is sufficient demand from the market place to turn this into a viable business.

'There are a couple of operators who've looked at larger aircraft for jobs such as power line inspection, but the commercial case hasn't

been made yet,' added Gibson. 'I was talking to one company recently who were carrying out power line inspections with manned helicopters and I asked whether they'd thought of using RPAS. They said they'd looked into it, but it wasn't necessarily going to be cheaper and the manned helicopter gives them much greater flexibility about when and where they can fly.'

■ WIDESPREAD MISCONCEPTIONS

The small UAS authorisations – whether exemptions from certain regulations, as in the US, or permissions to operate the aircraft, as in the UK – get around some problems, but the model will not work in all cases. A widespread misconception is that these types of authorisations can be applied only to smaller, lighter aircraft. However, the key determinant factor is not the size and mass of the system, but the risk.

'Risk has nothing to do with weight,' Sivel pointed out. 'A 100kg aircraft doing aerial work above the Atlantic Ocean poses almost no risk – it would just fall in the sea and disappear. A 5kg RPAS filming a football game at Wembley Stadium, [London], poses a risk. And we do not think very-low-risk RPAS should be regulated in the same way as classical aviation was in the past.'

This approach, if adopted internationally, would remove the headache of type certification for many smaller UAS, albeit only those operating away from people. But for larger aircraft, there is unlikely to be a similar shortcut, and airworthiness has been a limiting factor in a number of UAS programmes, particularly in Europe.

Taking the RAF's Reapers as an example, the service is currently unable to fly its fleet in British airspace, in part because the aircraft (procured under a UOR) were fielded quickly,

and were never intended to meet European airworthiness regulations. The Reaper's OEM, General Atomics Aeronautical Systems (GA-ASI), is in the process of manufacturing a certifiable version of the aircraft based on its Block 5 configuration, but no timeline has been made public as to when it will be available.

■ CANCELLED PROGRAMMES

Meanwhile, the German Air Force is still seeking a replacement for its cancelled unmanned Euro Hawk. Lt Col Roland Runge, the former lead officer for the service on the programme, told the Defence IQ UAS Training and Simulation conference in London in November 2014 that NATO's document governing airworthiness for UAS, Standardisation Agreement (Stanag) 4671, was what 'broke the back' of the project.

'In 2007, when we closed the contract, there was no Stanag 4671,' he said. 'But it was in force in 2010 when we brought [the aircraft] over [to Germany]. This is what it was tested against and obviously it was not up to the high standards that were required.'

By contrast, the UK's Watchkeeper system has taken a different route. There has been extensive criticism of the lengthy delays in fielding the platform. It was planned to take over from the British Army's leased fleet of Hermes 450 UAS at Camp Bastion in Afghanistan, but in the end it only made it to the country for a few weeks before UK forces withdrew at the end of 2014.

In the government's response to Parliament's Defence Committee special report on RPAS, published in July, the unnamed authors said: 'An underestimation of the challenges of delivering sufficient quality evidence to underpin the Watchkeeper system safety case led to the delay to the achievement of the system's release to service... The need to develop an early understanding of airworthiness certification requirements was a key lesson from the Watchkeeper programme.'

■ MAKING HISTORY

Yet, at the end of the extended process, and with very little fanfare, the UK has acquired a UAS that meets airworthiness regulations. ➤

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AIRSPACE INTEGRATION

As a result, Watchkeeper may make history this spring when, if all goes according to plan, it makes the first beyond-line-of-sight (BLOS) flight by a UAS in UK civil airspace.

This is dubbed 'Project CLAIRE', ostensibly standing for Civil Airspace Integration for RPAS in Europe. It is a demonstration being run by a number of bodies, including: Single European Sky ATM Research Joint Undertaking (SESAR JU), an EU programme to modernise and standardise European air traffic management systems; NATS, the UK's air traffic control provider; Thales, lead systems integrator for Watchkeeper; and the National Aerospace Laboratory of the Netherlands.

The aim is to make a number of flights – expected to be three – of a Watchkeeper from West Wales Airport, where there is already a large



Dedicated test ranges are vital for OEMs while civil airspace remains inaccessible. (Photo: Vidsel Test Range)

block of airspace segregated for UAS activity. 'The plan is to fly the aircraft out of West Wales Airport, up to Danger Area 201 and climb to height, then actually make the break from segregated airspace into controlled, [but non-segregated] airspace,' Corbett told the UAS Training and Simulation conference.

'Initially, it will do one flight out to sea; the second flight will be [out of segregated airspace over land] and back; and then possibly a third flight towards Cardiff Airport. At one time, it was going to do a practice diversion at Cardiff, but now the plan is to stick at about 11,000ft, fly around and then come back to the danger area.'



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The aircraft will fly in controlled airspace, with separation conducted through air traffic controllers. Corbett expects the flights to be similar to the six transits of UK airspace made by a Global Hawk in May 2014, which were so incident-free as to be 'intensely dull and boring'.

■ DIFFERENT PROPOSITIONS

The Global Hawk transits were very different propositions to the CLAIRE flights however, as that the aircraft was operating at 54,000ft, well above other air traffic, and the airspace between 50,000 and 60,000ft was temporarily closed. The Global Hawk avoided low-altitude UK airspace entirely – it took off and landed at Sigonella in Italy and its operational orbit was off the coast of Norway.

'It wasn't exciting by any means,' Corbett continued. 'But that's because there was nothing up there and no conflicts to deal with. Perhaps that's the next step, when we try to mix things elsewhere.'

By contrast, the CLAIRE flights of Watchkeeper will require a number of other considerations for pilots and air traffic controllers alike.

The question is, of course, what happens if something goes wrong – if the engine fails, for example,' said Corbett. 'There has to be controlled airspace, so we're going to have to do some sort of temporary segregation beneath the airway as well to allow it to go somewhere for emergency landings. However, that doesn't mask the fact that we will try our best to push the boundaries a bit while we're flying down in controlled airspace.'

Provided no major incident takes place, the greatest pressure during the experiment is likely to be felt by the controllers.

'One of the things so far from the simulations dealing with the Watchkeeper is that it's just painfully slow,' he continued. 'It goes about 60, 80kt most of the time. So it's like controlling helicopters versus controlling a jet – the helicopter's virtually stationary at times. And so invariably everything else will be routed around it, because it won't be able to be moved out of the way quickly. But that's one of the lessons to learn.'

■ SENSE AND AVOID

The key technical obstacle, particularly for those phases of flight in which a BLOS aircraft needs to fly in unsegregated airspace, and ➤

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Common sense to avoid?

A simple solution to minimise the possibility of mid-air collisions involving UAS is under discussion in Poland. During his presentation to the UAS Training and Simulation conference in London in November, retired Polish Air Force major Grzegorz Trzeciak revealed a proposal for how UAS should be given right of way in unsegregated airspace.

'It comes from general aviation, where we have balloons, gliders and engined aircraft,' he explained. 'The glider should give way to the balloon and the aircraft with the engine should give way to the glider. Why? Manoeuvrability. Also, the UAV is blind. Blind people on the street have right of way. They also have a white stick and the UAV should be bright – lots of lights.'

For flights within visual line of sight, the responsibility to avoid collisions would rest with the UAS pilot. However, in BLOS operations, it would be up to the manned platform to avoid the UAS, not the other way around.

The proposal has been opposed, but, according to Trzeciak, a certain brand of wry logic has helped keep the idea under consideration.

'They told us: "OK, you need to put a sense-and-avoid system on board,"' he continued. 'And we said: "We can do that, but you need to put engines on balloons. Why? For safety!"'

The proposal does not envisage this as the only means to achieve separation, nor is it intended as an excuse to avoid developing technical solutions. As a pragmatic stopgap and a backup when automated systems may malfunction, Trzeciak insists it has potential. However, he will face an uphill battle to get the proposal widely adopted.

'There could be a future in an idea like that,' JARUS's Eric Sivel told UV. 'But for the moment, we have been asked at all levels that the integration of unmanned aircraft into the airspace must not affect manned aircraft. It's effectively up to the unmanned aircraft to solve the problem, not manned aircraft. Maybe afterwards, if we can't do it, we'll have to go towards the Polish solution. But for the moment, I haven't heard of anybody changing that official position that we have to follow.' **uv**

especially in proximity to general aviation traffic, is the creation, fielding and certification of a system that can automatically detect other aircraft on a potential collision course and ensure the UAS can take evasive action. In Corbett's assessment, the outcome of a successful project such as CLAIRE will be limited by the availability of sense-and-avoid technology.

'Even if [CLAIRE] is successful, this doesn't open the door to unmanned aircraft instantly getting into the civil airspace system,' he said. 'I think the bottom line will be that you'll need some sort of collision avoidance system within the aircraft to ensure you can jump out of the way of other aircraft if you have to go into Class G [unsegregated, uncontrolled] airspace.'

Manufacturers of larger UAS are hard at work on solutions to the sense-and-avoid problem.

GA-ASI was, as UV went to press, about to announce details of a second phase of tests of its proprietary system that took place on board NASA's modified Reaper testbed, known as Ikhana, in December.

Northrop Grumman is concentrating on a range of subsystems for the USN's Global Hawk derivative, Triton, which, the company believes, will give the aircraft equivalence to manned aircraft in many of the key areas where technology at present limits operations.

Yet, the technologies will only help if they can be certified. Part of the log-jam in the airspace integration arena appears to have been caused because industry is waiting for regulations, while regulators are waiting for technologies to write regulations for. And with a plethora of different bodies – national and international – all looking into the problems, a continuing stand-off is perhaps understandable.

Until it is clear whose regulations will be adopted, there is little commercial sense in an airframer or integrator spending valuable research resources on building a prototype system.

FORMING A CONSENSUS

Encouragingly for industry, a consensus appears to be forming around the route by which internationally complementary regulations might best be drafted.

'We in Europe are pushing for JARUS to be the vehicle that makes the link between all the main initiatives,' explained Sivel. 'The first step was that EASA was elected to chair JARUS and the FAA was given the vice-chairmanship. Eurocontrol [the European air traffic control coordination organisation] heads the secretariat.'

This brings air safety organisations from Europe and the US together with air traffic controllers at the head of the organisation.

JARUS has no rule-making authority – it can only make recommendations that other bodies can choose to adopt, or not adopt, but this may be its biggest strength. Its membership is not limited by geography and it can build consensus without having to enforce any edicts.

At present, JARUS includes members from Australia, South Africa and the US. Approaches have been made to both China and Japan, and Sivel expressed optimism that both will agree to get involved before the end of 2015. That would put experts from almost all the nations currently most heavily active in RPAS under the same organisational umbrella and enable dialogue, information-sharing and joint work on standards and regulation drafting to take place in a global, rather than local, forum.

'We have a chance here of having harmonised rules, which was the idea behind having JARUS coordinating,' added Sivel. 'If the recommendations are in line with the worldwide system, each national system won't be too far away from each other. If we're successful, we'll have a common set of rules throughout the world. That may be wishful thinking, but at least we'll have a common basis for all these rules, which is something that we don't have in manned aviation.'



RAPSODY

TEKEVER Unmanned System selected for pioneering maritime surveillance

The new unmanned aerial system AR5 Life Ray, developed by the TEKEVER Group, was selected by the European Space Agency (ESA) and the European Maritime Safety Agency (EMSA) to create the first drone-based European maritime surveillance system.

RAPSODY, a project led by TEKEVER, will test the use of unmanned aerial systems in a maritime context through real-world demonstration of two scenarios: search and rescue missions; and pollution and oil spill monitoring. The systems will operate over the Atlantic Ocean, the North Sea and the Mediterranean Sea. This is the first time unmanned aerial systems will be introduced into maritime surveillance missions in Europe.

This is a significant two year long project. The first year will be dedicated to the integration of the various sensors that will board the aircraft, developing on-board sensor algorithms to improve operational performance, as well as optimizing data transmission according to the type of missions that the system will carry out. In the second year of the project, there will be tests and demonstrations that will put the system in real scenarios and prepare it for a fully commercial use.

"The AR5 Life Ray Evolution is one of our larger platforms. With a wingspan of 4.3 meters and a payload of 50 kg, the AR5 is capable of performing 8 to 12 hours missions and has the most suitable design for the

RAPSODY project. With the use of satellite communications, our system is geared to perform multiple types of long-range missions, including search and rescue, surveillance and maritime patrol and pollution detection, among others", explains Ricardo Mendes, COO of TEKEVER. "The AR5 is a clear advance in our systems, providing an excellent way to complement maritime surveillance operations, with a lower cost and greater flexibility than manned systems, as well as responding to the huge challenges posed by the European maritime space".



AR5 Life Ray Evolution

The AR5 Life Ray Evolution is an unmanned aerial system designed for mid and long-range maritime surveillance missions.

Capable of carrying 50kg in 8 to 12 hour missions, the AR5 provides multiple payload bays and hard points, specifically designed to support a wide range of payloads including, among others, high-definition and infrared cameras, synthetic aperture radars, LIDAR and AIS.

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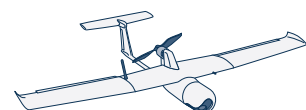
AR1 Blue Ray

AR1 is a fixed-wing UAS, designed for security forces, that delivers advanced information, security, surveillance, monitoring and reconnaissance capabilities in the most challenging urban and rural conditions. AR1 has an endurance of up to 2 hours and a mission radius of 20Km.



AR3 Net Ray

AR3 is a UAS designed to support multiple mid range missions, including Intelligence, Surveillance, Target Acquisition and Reconnaissance. The AR3 has an endurance of up to 10h, and offers an operational range of 120 Km.



AR4 Light Ray Compact

AR4 Light Ray Compact is designed for Intelligence, Surveillance, Target Acquisition and Reconnaissance missions. With an MTOW of 1,5Kg, the AR4 can fly up to 45 minutes at a cruising speed of 57 km/h and has a mission radius of 5 km.



AR4 Light Ray Evolution

The AR4 Light Ray Evolution is the ideal system for Intelligence, Surveillance, Target Acquisition and Reconnaissance missions, flies up to 2 hours at a cruising speed up to 57 km/h and offers an operational range of 20 km.

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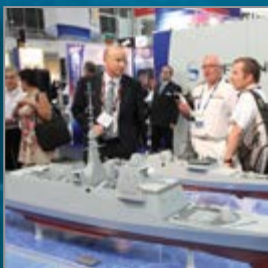
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Up and coming

Unmanned VTOL systems are gaining favour with civil and military customers, particularly in the maritime arena. **Claire Aphthorp** talks to some of the UAS developers leading the way to find out why.

Recent development work on Skeldar is focused on the integration of a multi-sensor intelligence cell to enhance its ISR capabilities. (Photo: Saab)

A common refrain heard throughout the VTOL UAV sector is that it is a market poised for take-off. Contract awards for systems not actively supported by military programmes remain few and far between, but this is changing.

Some of the manufacturers *Unmanned Vehicles* has spoken to describe how customers are facing a 'culture clash' when introducing unmanned assets into existing structures, while others are battling with budget constraints and struggle to match VTOL options to demanding requirements.

Much of the potential to deploy large numbers of VTOL assets is in the maritime arena.

The USN's MQ-8C Fire Scout programme continues, with the first operational system delivered by Northrop Grumman in early December. This aircraft – essentially an unmanned Bell 707 helicopter – is the first of 19 units that will be supplied by the company to the service as it works to improve the intelligence-gathering capabilities of ship-based commanders.

The aircraft flew for the first time from the USS *Jason Dunham* (DDG-109) on 16 December, proving it could be controlled from the ship's GCS. The test programme will continue throughout 2015, with the aim of commencing operations by year-end. If efforts are successful, the navy could go on to purchase up to 70 Fire Scouts, offering a game-changing capability.

GETTING TO GRIPS

Saab has also marked an early victory in the maritime market with the Spanish Navy becoming the first user to operate the Skeldar V-200 UAV from its naval vessels under an agreement signed in 2013. The Skeldar V-200 was deployed from the BAM *Meteoro* offshore patrol vessel (OPV) in support of anti-piracy missions in the Gulf of Aden.

However, reports suggest that testing during the deployment was not trouble-free, with issues encountered relating to the sensor suite and integration with the ship's electronic systems. This deployment complete, Saab continues to seek a customer for Skeldar, with

the latest development focused on the integration of a multi-sensor intelligence cell to enhance its ISR capabilities.

Integrating UAS with a ship's electronic systems poses a challenge to all VTOL UAV manufacturers, as does the harsh maritime operating environment, where weather, limited visibility and an unstable landing and take-off base create difficulties.

The Swedish Navy has also taken an interest in a UAV capability, selecting CybAero's APID 60 VTOL system in December last year. Mikael Hult, CEO of the company, told *UV* that issues with shipboard integration pose a challenge to VTOL suppliers looking to target the naval market.

'It's quite a complicated environment to operate from a ship, firstly because the platform is moving, but also because the steel-heavy environment of the deck poses difficulties such as noise and disturbances to the air control system,' he said. 'Secondly, to integrate our C2 system with the ship's existing systems is a complex process – for example, the ship's radar systems can interfere with the UAS C2 system.'

LEVERAGING EXPERIENCE

CybAero's APID 60 grew out of an earlier programme to develop a VTOL UAV for the UAE armed forces known as the APID 55. With that programme indefinitely on hold due to the nature of the tough operating environment, CybAero worked with Indra and AeroVironment to leverage their collective knowledge and experience into developing the APID 60.

With an endurance of six hours, a length of 3.2m, an MTOW of 180kg and a payload and fuel capacity of 50kg, the APID 60 is close in specification to the Schiebel Camcopter, but Hult is confident that some aspects of its design give it the edge over the competition.

'One major difference is that our product gives the customer the option to perform all

maintenance on-site – on the deck of a ship or in the desert or wherever it is operating – it doesn't have to be shipped to a maintenance location, which is a big advantage compared to Schiebel,' he said.

Although recent development of the system has occurred within the maritime market – the company will deliver three ship-based systems to its first customer, China Customs, in Q1 and

Q2 this year – the APID 60 is available with a choice of gasoline or heavy fuel engines to cater to both the sea and land sectors. However, Hult believes that 2015 will be the year of the maritime market.

'I think there will be a breakthrough in maritime applications – we have noticed a tremendous increase in interest,' he said. 'That's not to say that there will be a lot more



Schiebel is currently working on the OSCE Special Monitoring Mission in Ukraine with Camcopter. Two have been deployed in the southeast of the country. (Photo: Schiebel)



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installations this year – it may take some time still – but I do believe we will see more orders from the maritime side.’

Sweden is scheduled to begin APID 60 flight tests in August, with CybAero set to undertake integration work in the spring.

SERVICE PROVISION

Schiebel says it is seeing continued interest in its Camcopter S-100. In June 2014, the company demonstrated the platform to the Brazilian Navy, with a number of sorties being flown from the *Amazonas*-class OPV *Apa* off the coast of San Pedro to allow the authorities to evaluate the capabilities of its payloads, including the L-3 Wescam MX-10, Selex ES SAGE ESM and PicoSAR radar and Automatic Identification System.

According to Hans Georg Schiebel, chairman of the eponymous company, the demonstration was a success and he now awaits the customer's RfP, which is expected within the next three to four months.

The Camcopter S-100 is capable of operating day and night, under adverse weather conditions, with a beyond line-of-sight capability out to 200km, both on land and at sea. The aircraft navigates via pre-programmed GPS waypoints or is operated with a pilot control unit. Missions are planned and controlled via a point-and-click GUI and HD payload imagery is transmitted to the control station in real time. Fly-by-wire technology and a triple-redundant flight computer allow for automatic missions.

Schiebel says it will not be conducting a great number of demonstrations in 2015, as it is focusing on supporting existing customers and growing its service provision capabilities.

‘We are extremely busy supporting operations with the Italian Navy, as well as flying 24 hours a day in the Ukraine at present,’ Schiebel said. ‘So while we have some prospective customer activities planned for this year in the Pacific Rim region, we are quite stretched with the work we have at hand.’

The Italian Navy is one customer that Schiebel will be looking to support this year. The navy selected the Camcopter S-100 in

February 2014 and the company backs up its operations in the Mediterranean Sea with a service provision arrangement.

The UAVs have been operating as part of the Migrant Offshore Aid Station (MOAS) operation to locate and identify

refugee vessels in distress in cooperation with the Rescue Coordination Centre. The UAV will also shortly deploy on the Italian Navy's *Maestrale*-class frigate *Grecale* to the Horn of Africa for ongoing anti-piracy operations.

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K-Max has recently demonstrated its ability to be used as a fire-fighting asset using an SEI Industries Bambi Bucket. (Photo: Lockheed Martin)

INTELLIGENCE GATHERING

Elsewhere, Schiebel is under contract to provide, fly and maintain Camcopter S-100s on behalf of the OSCE Special Monitoring Mission to Ukraine. The first two aircraft arrived in Kyiv in October and are being deployed near Mariupol in the southeast of the country to enhance existing monitoring capabilities, primarily for border and ceasefire monitoring.

This is crucial work – the platforms are monitoring the concentrations of weapons, military movements and installations and infrastructure damage, with the information then reported to the 57 participating states of the OSCE to provide a more comprehensive picture of the current security situation on the ground.

According to Schiebel, the flights take place mostly along the contact line and within the 15km 'cessation of use of weapons zone' on both sides of the contact line where heavy weapons and equipment are prohibited according to Minsk Memorandum, which was signed by all parties to the conflict on 19 September and allows UAV observation to be conducted exclusively by the OSCE.

These service-provision-type arrangements have potential to further unlock the VTOL market, Schiebel believes, helping overcome any negative perceptions by some potential

users that are currently acting as a barrier to acquisition.

'For example, in the Pacific Rim we have a potential customer who has previously used drones from another manufacturer to monitor power lines, and although the fleet performed well and the customer was happy with the results, the fleet was lost in a very short amount of time,' added Schiebel. 'So our job now is to find new approaches with local partners to sell the service instead of selling the kit.'

'That way the customer has the peace of mind that they will get the data they need and it's not their problem if an aircraft is lost, but it takes some time for the clients to accept that. There's still a lot of ground work to be done, but we are doing it and it will happen.'

TEAMING UP

New competition to Camcopter has emerged in the shape of Airbus Defence and Space's Tanan UAV, which is to be integrated with a combat vessel under an agreement with shipbuilder DCNS announced in October.

With a payload capacity of 80kg – exceeding the Camcopter's 50kg – and an endurance of eight hours, Airbus is targeting payload flexibility with Tanan.

'The 80kg allows us to offer a dual-payload configuration where we can combine a radar

with an EO/IR sensor, so the customer can choose to have both, or choose to focus on one configuration, or even modify the payload to do communications relay or electronic surveillance,' Jens Nielsen, head of UAVs at Airbus, told *UV*. 'The market has shown us that today it is looking for a dual-payload configuration to have the highest possible flexibility.'

DCNS plans to integrate the UAV into a new-generation FREMM frigate or light multi-purpose *La Fayette* class – the final decision is yet to be made, but the expectation is that it will be a next-generation future stealth-type frigate. What is interesting about these vessels is that designs are moving down in size, potentially opening up a market for UAV VTOL aerial support in place of the helicopter.

Tanan is currently in its flight test programme and Nielsen expects delivery to DCNS will take place early in 2016. One Tanan package will consist of two aircraft and a ground control system, but the total number of units that will be delivered to DCNS is still under discussion.

'When we deliver the system, DCNS will conduct operational testing on the ship which will take some time throughout 2016,' continued Nielsen. 'As soon as those tests are done, they will make a decision as to how many they will take.'



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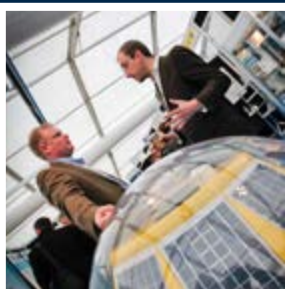
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MID-RANGE SOLUTIONS

Down the size scale, Aero Surveillance unveiled a new addition to its range of VTOL UAS at the International Airborne Maritime Surveillance Exhibition in Le Castellet, France, in December. The ASV100 builds on the company's existing ASV150 and ASV200 portfolio, targeting the maritime operations sector.

With a useful payload of 20kg, MTOW of 40kg and endurance of four hours, the ASV100 is the smallest of the Aero Surveillance rotorcraft UAV portfolio. It has been developed to operate from vessels for shipboard surveillance operations and Philippe Roy, president of the company, explained why.

'Naval vessels do not carry gasoline on board, they only carry aviation fuel and asking them to carry additional fuel – especially in small amounts – is a nightmare from a logistics standpoint,' he said. 'So we developed the ASV100 with a turbine engine and also with a full fuselage to provide more protection against the environmental elements.'

The ASV100 is smaller than Skeldar and Camcopter and Roy believes that this size range will become increasingly attractive to customers looking for an alternative that is able to perform many of the same operations at a lower price point.

'I think that sometimes people have been considering the larger machines because at that time they were the only options available – when you look at the operational requirements, a smaller machine could do it better,' he said. 'Particularly when you consider that a smaller machine that allows you to purchase two to three units for the same price as one larger system opens up operational options such as surveilling more than one area at once.'

The ASV100 is already attracting interest, with an unnamed customer currently carrying out testing and evaluation of the system, but whether the maritime market will be as big as expected remains to be seen.

Roy added: 'Time will tell, but we are certainly seeing a lot of demand in the form of RfPs and RfIs as customers look to assess their options.'



The first operational MQ-8C Fire Scout unmanned helicopter was delivered to the USN in early December. The service could go on to buy 70 of them. (Photo: Northrop Grumman)

GROUND WORK

VTOL systems are proving themselves increasingly useful in the land domain as well, with new applications for the technology emerging all the time.

Lockheed Martin's K-Max unmanned helicopter returned from its three year deployment in Afghanistan with the USMC in July 2014 and the company is currently investigating new applications for the system.

In November, it teamed with Kaman to demonstrate the aircraft's ability to perform autonomous fire-fighting operations in cooperation with the Indago quadrotor UAV. During the demonstration, the Indago identified hotspots and provided data to operators who directed the K-Max to autonomously deliver water to the flames. In total, more than 10,800kg of water were lifted and dropped onto the fire.

'We didn't have to make many changes to the configuration we had in place for the USMC for the autonomous water collection,' said Jon McMillen, business development manager for

K-MAX at Lockheed Martin's Mission Systems and Training business. 'We had already optimised long-line heavy-lifting operations, the difference we had here was that when picking up the load of water we had to dunk the basket in and wait for it to fill, but that's still just hovering over a point – the same as performing a retrograde operation in Afghanistan.'

'In terms of releasing the water, we just had to be able to open the bottom of the basket during flight, and all those things we have done time and time again.'

The motivation for the demonstration followed discussions with fire-fighting organisations about the challenges faced during a typical mission – namely the restricted flight hours able to be undertaken by manned aircraft.

'They are only able to fly under certain visual flight conditions, so they can't fly at night or when there is a lot of smoke in the area, which typically adds up to only eight hours a day when they can be performing aerial fire-fighting missions,' continued McMillen. 'The ➤



The Tanan UAV is to be integrated with a combat vessel under an agreement with shipbuilder DCNS. (Photo: Airbus Defence and Space)



UAV Solutions has delivered four Phoenix 30 quadrotors to the Bulgarian Army. (Photo: UAV Solutions)

other issue is they are only able to resupply or extract smoke jumpers when the aircraft are flying, which means during the day or under very limited conditions with NVGs.

'When we looked at the missions K-Max performed in Afghanistan – night operations with visibility not an issue – we saw good alignment between what we have and what they are looking for, with the potential to provide a 24/7 fire-fighting capability.'

■ QUAD CORE

Quadrotor VTOLs (such as Lockheed Martin's Indigo system) are seeing something of an upturn in the military market. In December, UAV Solutions announced that it had delivered four Phoenix 30s to the Bulgarian Army under an FMS contract with the US government.

The quadrotor is around 0.5x0.5m, weighs approximately 4.5kg, carries a maximum payload of 0.9kg and has an endurance of 25-30 minutes. It requires no assembly and takes only a few minutes to deploy, making it ideal for soldiers to operate.

The system is one of three quadrotors in the UAV Solutions portfolio, including the larger Phoenix 60 – a 0.75x0.75m system with a payload capacity of 1.4kg and range of 1.6-3.2km LOS; and the smaller Phoenix 15, a 0.4x0.4m system with an endurance of 20 minutes.

The concept and aim of the Phoenix family is to provide advanced technology at a relatively low price point, both for the military and paramilitary markets.

'One of our first exposures to this market was the Department of Homeland Security's Robotic Aircraft for Public Safety programme,' said Bill Davidson, CEO and chief engineer at UAV Solutions. 'While we were preparing for that we noticed that while the capabilities were very similar to the equivalent DoD system, the Aeryon Scout, the price point was significantly lower. Now, because of budget cutbacks, militaries also see Phoenix as a viable solution because it's the same technology they are used to but at a much more affordable cost.'

UAV Solutions is now working to expand the operational envelope of the Phoenix family in order to increase range, reliability and robustness. In addition to standard payload packages (combined EO/IR for Phoenix 15; pan and tilt EO/IR network/IP-based camera for Phoenix 30; and dual camera, EO and thermal imager, pan-and-tilt stabilised gimbal for Phoenix 60), the UAVs can carry a range of payloads from third-party suppliers.

'The amount of technology that is emerging at this price point is almost unbelievable,' Davidson continued. 'Low-cost sensors, autopilots, IP-based communication solutions – it is all evolving so quickly and is as good as what we are used to seeing in the DoD space.'

■ AREA OF INTEREST

The company says it is also seeing interest for law enforcement, pipeline and power line monitoring and agriculture. Davidson believes that the quadrotor's inherent value proposition

will continue to spur growth in the military market however.

'A lot of the military branches have done all the procurement they are going to do on fixed-wing – they are very satisfied with their Puma and Raven systems,' he said. 'But VTOL remains something that is of interest, so I think we are going to see pretty large movement on the military side for these small multi-rotors at some point.'

'These systems are man-packable and portable, unlike larger systems that take days to get into operation, and they are an organic asset to the infantry and able to be deployed typically within five minutes or less.'

Davidson believes that while the market is flooded with options in the Phoenix family size range because the components at this level are relatively inexpensive, there is space in the sector to move towards both larger and smaller technology.

'There are a lot of requirements emerging for pocket-size systems and that is one of the things we are working on, to develop a system at that size that is robust and reliable,' he said. 'While you can use off-the-shelf components for micro-sized systems, it does take a little more engineering to make them as small as possible.'

'Many requirements want them to work with smartphones on 4G and 3G services, so it's moving towards a point where a soldier will pull a micro, organic aerial asset out of their pocket that works with the cellphone or tablet that they already own and are familiar with.' **uv**

China's indigenous unmanned vehicles industry is clearly playing catch-up with Western manufacturers, but it is starting to close the gap and seize export opportunities. **Gordon Arthur** examines the country's recent technological advances and asks: what next?

Out of the red

The capability of China's unmanned vehicle industry is maturing. Numerous companies and institutions are designing, experimenting with and producing craft, and if the recent air show in Zhuhai was indicative of the country's intentions, then it's set to become a major force on the export scene too.

Felix Oehl, technical director at Aerobots, Hong Kong's largest aerial imaging company, said that he is certainly seeing more happening with UAVs in China's commercial sector. 'Aerobots has seen quite a bit of interest from China in the more industrial applications of UAVs,' he explained. 'Mainly projects from aerial

photography/video to surveying, inspection and even emergency response.'

This may be partially due to the country's size and the inaccessibility of certain areas.

'Compared to Europe and the US, China seems to have a slightly more pragmatic approach in looking towards larger-scale applications where UAVs could have a big impact on safety and cost,' continued Oehl. 'The expansion of technology has been incredibly fast and the products coming out now are poles apart from where the industry was just two years ago. The adoption of the technology seems to be a little slower though, partly because people don't know what the technology is

capable of – and some are surprised at how much it can do.'

ARMED RESPONSE

However, this is also down to regulations, as illustrated on 29 December 2013 when a UAV strayed over Beijing, prompting a major military operation where 1,226 troops, 26 radar technicians, 123 military vehicles, two fighters, two helicopters and surface-to-air missile systems assumed battle stations. An armed helicopter shot the aircraft down because it represented a security threat to Beijing Capital International Airport. Three people from an aviation technology company performing mapping of real estate developments were later arrested.

The Wing-Loong 1 UCAS, which has several export customers, was proudly exhibited at Airshow China 2014 in PLAAF markings.

(All photos: author)



In China, operators need a licence to fly a UAV heavier than 7kg and, if it is more than 116kg and operating in integrated airspace, the operator must have both a pilot's licence and UAV certification. Airspace below 3,300ft is controlled by the People's Liberation Army (PLA), so permission is required from the military before take-off. Nevertheless, because of complicated application procedures, it is common for small aircraft to fly without gaining requisite approvals, plus expansive rural areas mean UAV operation is much easier. The Aircraft Owners and Pilots Association estimates there are some 10,000 professional UAV pilots in China, a figure growing rapidly.

Oehl said the biggest commercial UAV manufacturer is DJI, which has done for the personal UAV industry what Apple did for the personal computer. He added: 'Civilian UAVs



Xi'an ASN Technology is the biggest UAV manufacturer in China, and its tactical UAVs are a mainstay in the PLA. These ASN-207s appeared in Beijing's 60th anniversary parade.

were complex, kit-based products that required the customer to buy various parts from various manufacturers in many different countries and put them together themselves... DJI have created user-friendly products designed to be used out of the box with very little learning curve.'

■ PEACE MISSION

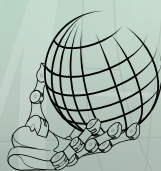
Last year was the most informative yet as the PLA Air Force (PLAAF) lifted the cloak on its deployment of UCAS. In August, the service

showcased imagery of a missile from an armed CH-4 hitting an 'enemy' vehicle during the multilateral Exercise *Peace Mission 2014*. Feng Aiwang, commander of a PLAAF battle group, said the craft did not miss a single target in several missile firings. Li Pingkun, head of the CH-4 project, stated on TV that the craft could hit targets with a margin of error less than 1.5m. Without divulging details, he revealed the CH-4 'used several methods to guide missiles or smart bombs onto targets.'

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Manufactured by the China Aerospace Science and Technology Corporation (CASC), the CH-4 has an 18m wingspan. According to company literature, two variants exist: the 1,260kg reconnaissance CH-4A, with a 30-hour endurance and 3,500km range; and the armed CH-4B, with a shorter 14-hour endurance and 1,600km range, but carries a heavier 345kg weapon payload of laser-guided missiles and small guided bombs on four hardpoints.

The PLA has engaged in something of a publicity campaign to gain support for the military use of UAVs. State media has reported that the military deployed UAVs in restive Xinjiang Province to help hunt terrorists. Indeed, Shen Jinke, a *Peace Mission* spokesman, commented: 'The drone, tasked with surveillance, reconnaissance and ground

attacks, will play a vital role in fighting against terrorism.'

CASC has been slow to achieve UAV sales to the PLA, and the CH-4 is believed to be the company's first platform to win orders. In a concerted marketing campaign, CASC is targeting Africa and Asia, with Algeria allegedly testing the CH-4 earlier in 2014. *Kanwa Asian Defence* reported that Pakistan is negotiating to import the type too.

The CH-4 is a direct competitor to the Wing-Loong 1 built by Chengdu Aircraft Industry Group (CAIG). At Airshow China 2014 in November, a Wing-Loong 1 (also called Pterodactyl 1), was exhibited in PLAAF livery surrounded by an array of guided munitions.

Andrew Erickson, associate professor at the strategic research department of the US Naval

War College, commented to *Unmanned Vehicles*: 'One of China's first export UAVs, it appears to have been developed rapidly (over 5-6 years) to capitalise on a potential market niche that the US has left open through self-restriction to support arms control ideals.'

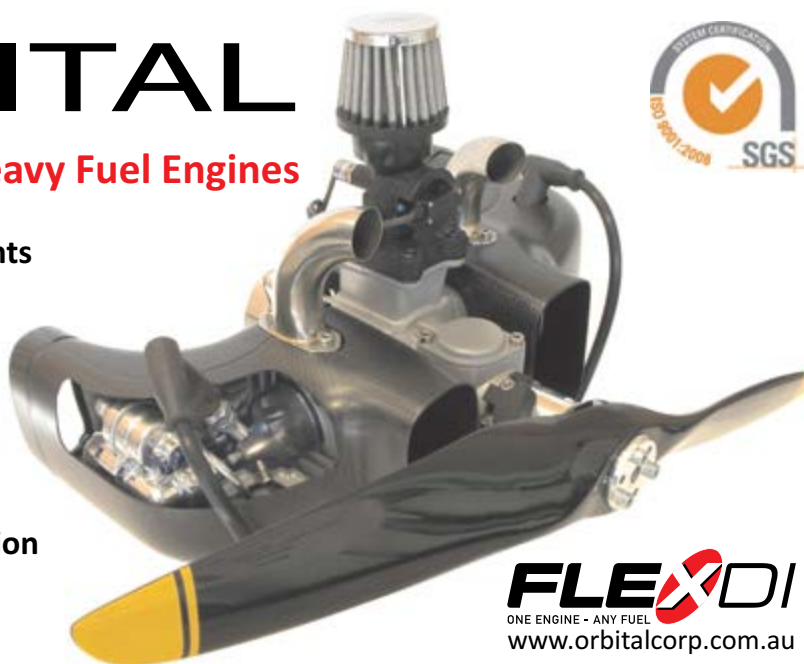
Visually similar to General Atomics' Predator (but reportedly available for a quarter of its \$4 million cost) and armed with air-to-ground missiles, the Pterodactyl is advertised as the only freely available UAV capable of both reconnaissance and strike. It will enter series production this year, and its bread-and-butter PLA mission is likely to be border patrol.

According to data from the manufacturer, the Wing-Loong 1 weighs 1,200kg, has a 14m wingspan and a range of 4,000km and endurance of 20 hours.



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'It will likely appeal to a range of Middle Eastern and Asian customers,' continued Erickson. The UAE and Egypt may already have procured it, while Uzbekistan and Saudi Arabia are said to be closely considering purchases of their own. It is intriguing that the PLAAF is operating two very similar MALE UCASs – the Wing-Loong 1 and CH-4 – side by side. This is reflective of China's state-owned industrial sector where the government must ensure every corporation receives regular orders to keep workforces employed.

■ NEW DESIGNS

By 2005, China had adopted a licensing system that allowed the private sector to compete for defence projects. One reason for this was that civilian experts in the country were the only ones who conducted any UAV development up until the late 1990s. Correspondingly, at the Zhuhai air shows there has been a plethora of UAV concepts and models, although most never reach production.

Erickson added: 'The profusion of UAV programmes and products is merely one of the more prominent examples of a significant trend across China's defence industry. Burgeoning national resources, and a delay in diversion to other societal priorities that could ultimately close the window on this golden allocation era,

has enabled policymakers to lavish tremendous funding on multiple research institutes, conglomerates and production facilities.

'China's UAV sector benefits from a particularly dynamic combination of state-run enterprises, such as the PLAAF UAV Combat Laboratory [established in 2007] and the Committee on Planning for Aerial Vehicles [established in 2006]; and private concerns such as the Northwestern Polytechnic University ASN Technology Group in Xi'an.'

■ SHOW BUSINESS

At Airshow China 2014, there seemed to be a maturing of designs, with more production-ready craft on show. Erickson concurred: 'While the efficiency of translating these resources into fielded systems remains uneven and uncertain, in aggregate this has allowed for clever adaptations and rapid progress. Initial results are clearly visible at Zhuhai, in Internet photos and gradually in China's own forces. They will ultimately be visible in the foreign forces that Chinese entities supply.'

The Chengdu Aircraft Design and Research Institute (CADI) showcased its new Nimble-Loong. A spokesman told *UV* that this 30kg craft, with a 3m wingspan and 150km mission radius, was suitable for civil tasks such as meteorological measurements and patrolling

power lines, and accomplished its maiden flight in May 2014. The vehicle is launched by catapult and arrested by a suspended rope.

CADI also had a scale model of the fixed-wing VD200 VTOL UAV on display. Taking off like a helicopter, it transitions to fixed-wing horizontal flight, with a claimed top speed of 140kt. The advantage of the VTOL capability is that only a small site is required for launch. The VD200 has a 4.6m wingspan and its MTOW is 200kg. The designer lists its roles as civil applications, although stability during landings could be a potential issue for this type of design.

Another CADI craft on display was the Sky Wing 1 (SW-1), an 85kg UAV with three-hour endurance that is already in use with China's Ministry of Environmental Protection. It can take off via a runway or catapult.

Elsewhere, the China Aerospace Science & Industry Corporation (CASIC) added a jet-powered WJ-500 UAV to the larger WJ-600 that has been seen a couple of times before in Zhuhai. Its developer stated that the multipurpose subsonic craft can be used for regional surveillance, target indication, battle damage assessment and other missions. However, it is not confirmed whether the WJ family has ever entered PLA service.

Two versions of the WJ-600 are available (A and D models), although CASIC did not describe the differences. The WJ-600 can be used for reconnaissance (with a synthetic aperture radar (SAR) or EO equipment), plus it can perform strike missions when loaded with air-to-ground missiles. Cruising at up to 380kt, its ceiling is 26,200ft and it has a five-hour endurance.

Another UCAS displayed in scale model form was the Air Sniper II from the Guizhou Aircraft Industry Import/Export Corporation (GAIEC). A member of the Harrier Hawk family, the platform can carry a compact SAR system. The third-generation Harrier III has a blended wing body design with retractable undercarriage. Interestingly, AVIC artwork depicts a GCS that uses holographic projection to aid operator control of UAVs. However, the fact that no hard details were given suggests it is only conceptual.



NORINCO is marketing the rotary-wing Sharp Eyes III that carries a laser illuminator for missile and artillery precision strikes.



In the foreground is NORINCO's Sharp Claw 1 UGV. Behind it is a six-wheeled transporter and a stowed small quadrotor UAV.

PLA SERVICE

As with anything in China's secretive military, it is difficult to evaluate the number of UAVs in service. A mid-2011 report by Taiwan claimed the PLAAF alone had 280 units. An estimated 93% of military UAV programmes in China revolve around tactical-level platforms. The largest manufacturer is Xi'an ASN Technology, which produces the ASN-206, ASN-207 and ASN-209 tactical reconnaissance craft for the PLA. Also fielded is the 200km-range, single-tail ASN-215. It is reported the company has delivered some 1,500 craft to the military.

The ASN-209 is believed to be in Egyptian service, and it was allegedly China's first UAV to be exported. At Africa Aerospace and Defence 2014 in South Africa, China exhibited an upgraded ASN-209G, an armed version able to carry two laser-guided missiles, with an upgraded data link system. To permit weapon carriage, the 4.27m-long ASN-209G carries less fuel and its endurance is thus reduced from ten to five hours. It has an MTOW of 320kg and cruising altitude is 9,800ft.

Since 2009, the Shenyang Aircraft Corporation and Hongdu Aviation Industry Group (HAIG) have collaborated on a stealthy UCAS design similar to Northrop Grumman's prototypical X-47B. This jet-powered craft, the Lijian (Sharp Sword), completed its maiden flight on 21 November 2013. It has internal bomb bays and a 14m wingspan, while the engine is presumed to be a Russian RD-93 turbofan. There is speculation it could eventually become a carrier-borne UCAS.

MALE DEVELOPMENTS

The Beijing University of Aeronautics and Astronautics and HAIG developed the BZK-005 MALE craft. It is believed to have been in service since 2009 with both the PLAAF and the country's navy (PLAN) for ISR missions. In 2013, China flew a BZK-005 near the disputed Diaoyu Islands, causing Japan to scramble fighters. It has a 40-hour endurance, 26,200ft ceiling and MTOW of 1,250kg.

Resembling an RQ-4 Global Hawk, the Xianglong (Soaring Dragon) HALE platform

built by GAIEC has a 7,000km range, and it seems destined for maritime surveillance. Its maiden flight occurred in 2009, and some speculate this craft or associates may eventually enable over-the-horizon targeting by weapons such as the DF-21D anti-ship ballistic missile.

CAIG makes the turbofan-powered Tianyi HALE UAV, a third-generation Sky Wing craft that may be in limited PLA service. It first flew in the mid-2000s, but last December CAIG revealed a modified design with rearranged fuselage incorporating two smaller turbofans to give it a lower IR signature.

A couple of times Japan has snapped photos of rotary-wing UAVs operating from PLAN frigates. It is unclear whether these are overseas or domestic designs, although there are certainly numerous platforms being developed within China. Examples include the V750 co-developed by the Weifang Freesky Aviation Industry Company, the U8E from Changhe Aircraft Industries Corporation, the TD 220 from Beijing ZHZ Technology Company and the co-axial RU100 and RU200 from DEA Helicopter Company.

The China North Industries Corporation (NORINCO) offers the Sharp Eyes III, which when equipped with CCD, IR and laser EO equipment is capable of performing target positioning, fire correction, battlefield situation reconnaissance and damage assessment tasks, according to the company. It can carry ➤

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FOREIGN COOPERATION

As well as indigenous capabilities, China is cooperating with overseas vendors in the civil sector. One such example is Schiebel and DEA.

'DEA has become the distributor of Schiebel products for the Chinese market,' a spokesperson from the former company told *UV*. 'Past sales were made and the expectation is to better serve the commercial market in China.'

Schiebel's focus is commercial applications where high reliability is important, eg infrastructure surveillance such as monitoring power lines and pipelines. Production of Camcopter S-100s will occur in Austria, with DEA conducting maintenance and support activities in China.

CybAero of Sweden was also at Airshow China 2014 in conjunction with strategic partners ACC Group and AVIC, showcasing its APID 60 rotary-wing aircraft. In July 2014, CybAero signed a framework agreement with AVIC to deliver at least 70 of the rotorcraft over the coming eight years. Last November, CybAero received a positive preliminary decision from Sweden's export control agency to deliver an initial ten systems to AVIC for civil applications.

UPS AND DOWNS

New UGV systems were on show at Airshow China 2014. State-owned NORINCO showed off an innovative triad of systems – a six-wheeled carrier vehicle, a Sharp Claw 1 tracked UGV and a small quadrotor UAV.

According to the manufacturer, the Sharp Claw 1 can be used by infantry troops to reconnoitre and hit enemy targets with little self-exposure, search and 'annihilate enemies' hiding in buildings and tunnels and rescue besieged friendly troops. The tracked robot was exhibited mounting a machine gun and cameras. For longer-distance travel, the Sharp Claw 1 is driven aboard its carrier vehicle, where the small quadrotor is also stowed.



This 1,600m³ aerostat is the second largest type in ECRIEE's range.

Another system unveiled at the show was the tracked Combat Robot. NORINCO and the China South Industries Group Corporation jointly presented this compact platform described as being useful for operations in 'small spaces and complicated environments'. The Combat Robot was fitted with a QBS09 shotgun, but its modular design allows it to perform EOD or sentinel tasks too, for example. The control system is carried in a backpack.

Meanwhile, East China Research Institute of Electronic Engineering (ECRIEE), a division of the state-owned China Electronics Technology Corporation (CETC), exhibited an aerostat at Airshow China 2014 for the first time. Four sizes of the Vehicular Tethered Aerostat System are available, ranging from 120m³ to 8,000m³. ECRIEE exhibited the second largest type (1,600m³). Company literature revealed it takes five hours to inflate and it can operate at a maximum altitude of 3,200ft for up to 20 days. The mooring station consists of a trailer unit towed by a truck to give the system a high degree of mobility.

Peng Guoliang, marketing manager at ECRIEE, stated that CETC produces both the envelope and payload, and that aerostats can be customised to client requirements. He noted that aerostats were used to support security operations during the 2008 Beijing Olympics and 2010 Shanghai Expo. The tethered craft are suitable for public security and surveillance, and can be fitted with communication equipment, IR cameras and SAR. *UV* understands that three aerostats have been built for China's security services to date.

Mobile airships from Jingmen Aviation Science & Technology, a subsidiary of AVIC, was also at Zhuhai. The company makes five

airship models, ranging from the 13.3m-long F6A through to the 56.1m-long JD60. It also produces aerostats ranging from the 150m³ JY15 through to the 1,500m³ JY150. The appearance of aerostats and airships signals that these are areas China continues to develop.

The State Oceanic Administration (SOA) is developing UAV bases in 11 coastal provinces, a programme scheduled to be completed this year, with a pilot effort running from Dalian since November 2011. The SOA also used a UAV in Antarctica for scientific research last year.

PRICE POINTS

Chinese suppliers have lower price points than Western competitors, one reason being that many designs are developed by academic institutions rather than industry. Unmanned systems R&D has been a priority for China since at least the early 2000s, but many of its designs thus far appear to be either close copies or looser emulations of foreign designs.

Erickson noted: 'However, major Chinese resource dedication and technical expertise in this area should ultimately yield more innovative, indigenously grounded designs that are closer in capability to those of world leaders such as the US and Israel. They may even come to encapsulate new approaches, such as incorporating features from China's already advanced cruise missiles.'

The export sector is clearly a focus for China. Erickson concluded: 'There should be export market segments open to China even at a lower level of technical sophistication. Given China's greater focus on developing armed UAVs, for instance, it is even conceivable that Russia might purchase them from China.' *uv*



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Pilot projects

The current focus for manufacturers of flight control systems is on a new set of capabilities. **Jonathan Tringham** reports on how advances in electronics are helping boost industry developments.

A number of new flight control capabilities are set to filter down from military-funded projects onto smaller UAVs in the coming years.

Speaking to *Unmanned Vehicles*, Ben Motazed, UAS marketing manager at Rockwell Collins, explained that capabilities like collision avoidance, sense and avoid, automatic take-off and landing, failure tolerance and redundant avionics are all making inroads – and much of the pace of development is down to the explosion in consumable electronics and more widespread ‘high-technology’ research.

He noted that the nature of the UAS business has changed dramatically – and very quickly. ‘Day to day, it is such a dynamic environment now, especially with the potential of commercial use,’ he said. ‘Ten to fifteen years ago, the challenge was just to keep the aircraft reliably up in the air. Today, it is a foregone conclusion that a lot of these platforms have autopilots.’

We’ve certainly seen this for ourselves. Many of the smaller-sized platforms like the quadrotors and mini fixed-wing UAS that are now selling in the millions have very inexpensive autopilots. According to Motazed, this is because these markets have significantly matured, fuelled in part by the surge in consumer electronics.

‘From a volumetric and market perspective, it is things like mobile phones and consumer electronics that continue to drive the investments made in sensor technologies and make them better, with higher performance, higher yield, increased miniaturisation and more power.’

‘It is things like mobile phones and consumer electronics that continue to drive investment in sensor technologies.’

SIDE BY SIDE

While autopilots help UAVs stay in the air, one challenge is in reliably flying them side-by-side with manned platforms, particularly in the case of larger systems. However, the level of certification and reliability to do this has to be on-par with manned aircraft, and in turn that means today’s flight control systems (FCS) need to ensure the UAV’s survivability in the event of any given failure.

‘If there is no man on board, the platform itself must not only be self-surviving, but able to find ways to avoid falling, crashing or abandoning in populated areas,’ added Motazed. ‘And of course all of these things have some kind of line-of-sight or beyond-line-of-sight man in the loop at the control station. However, with just-in-time C2, the latency that is in that system also has to be taken into consideration. Therefore, I think that one must know what a platform is going to do in the event of a failure and how it would mitigate that risk.’

Motazed points to the Joint Unmanned Combat Air Systems (J-UCAS) programme initiated by DARPA in 2008 to seek out a new survivability option that would allow an

aircraft to sustain flight and potentially continue its mission.

‘We started by blasting off an aileron and it eventually culminated in 80% of the wing – almost all the wing off one side of an off-scale F-18 getting blown off,’ he said. ‘And then the other surfaces as well!’

The technology developed from this is a ‘virtually instantaneous, autonomous assessment of damage incurred, followed by an immediate response that alters the FCS to compensate for the effects of that damage.’ Rockwell Collins was behind the damage detection and recovery software. The company also came up with the subsequent real-time reconfiguration of the control laws needed to maintain vehicle stability and control.

Motazed noted that if a UAV suffers damage in the air like this then recovery effected from a ground station is almost impossible, and the idea is that this type of technology will make its way onto future generations of UAVs and even manned platforms.

‘In the context of UAVs, you just never know what may happen,’ he continued. ‘You may get a strike from the ground, or it may be purely environmental and you lose your actuators, or in the case of a mishap – [with a survivability system] you can at least ensure you milk as much as possible of the control authority that remains in the platform and take advantage of it, stabilise the platform and bring it to a safe landing.’

LINKING DATA

Rockwell Collins is certainly making a name for itself, not only from taking part in blowing flight control surfaces off jets, but with its ARC-210 radios and the Athena family of FCS – these are now on several UAS, including the US Army’s RQ-7 Shadow, the RQ-4 Global Hawk operated

by the USAF and USN and the UK MoD's Watchkeeper WK450, considered to be the next largest tactical class platform outside of the US.

'We provide our data links to a number of platforms,' added Motazed. 'Our ARC-210 radios are very prevalent among the group four and five UAVs, so you see them a lot on platforms like the Global Hawk. We also played a central role in the development of the RQ-7 Shadow and provided an integrated inertial navigation system [INS]/GPS, air data, mission and payload processing all in one package.'

The Athena 411, for example, is a ruggedised INS, GPS, air data/attitude and heading reference system and FCS developed for both UAV and military applications. The unit integrates solid-state gyros and accelerometers, a magnetometer, GPS receiver and air data pressure transducers into a single module weighing 1 kg.

'A lot of these [Athena] products can host autopilot software within them as well, so you have one single box or unit that does all those key functionalities, significantly reducing the onus of the integration of the hardware onto the platform by the prime contractor or the end customer,' said Motazed.

■ GUARANTEED RECOVERY

Technology is now reaching a point where it is relatively inexpensive to add additional channels for 'triplex' redundancy, essentially guaranteeing recovery from any single point of failure.

Motazed explained: 'You can easily use these units as building blocks to implement redundant architecture and if a higher level of reliability is necessary, our architecture is very flexible. It is scalable so we can go from triplex to quad-redundancy, the hardware already

has all the IO built into it, so it can go from 10^{-7} to 10^{-9} probability loss of control, so essentially you can mitigate a lot of the uncertainty in the event of a failure that typically would not be fully covered in a dual-redundant architecture.'

Losing a UAV on military operations is one thing, but the situation changes dramatically when these same platforms are introduced into civil applications.

'A lot of these things are fluid right now and we are waiting for the small UAS rules to be released by the FAA,' explained Motazed. 'With certain classes and classifications of UAVs, certification will become a key requirement. In order for commercial UAS platforms to be viable, the level of reliability has to come at a reasonable price – it may be initially only relevant to the larger groups like the Global Hawks and those kinds of platforms. ➤



NASA's Ikhana is progressing nicely along the path to sense-and-avoid flight control systems. (Photo: NASA)

'Sense and avoid [SAA] is a big deal and such certification for the larger platforms eventually will become a requirement. These aircraft can be operated in line-of-sight or beyond-line-of-sight, but this opens up a whole new can of worms for us to deal with. Having full target command and control over these platforms is a big deal from a regulatory standpoint.'

■ ENABLING TECHNOLOGIES

According to industry leaders, if UAVs are to fly in non-segregated airspace then the enabling technologies required include: automatic take-off and landing capability with no man in the loop; robust SAA systems; and co-operative versus non-co-operative sensors between airborne platforms.

While these capabilities exist in varying levels of maturity, recurring safety and privacy concerns continue to dog progress. Several key regulators contend that the enabling detect-and-avoid technology is simply not mature enough, while others argue that this isn't the case.

Both Europe and the US are rushing to meet 2015-2016 deadlines to implement a



Eliminating the man in the UAS control loop is no easy task. (Photo: US DoD)

viable, wide-scale demonstration of UAV air insertion that is fully compliant with civil aviation rules, with each advancing SAA technology through a series of separate trials carried out in recent months.

In October 2014, for example, France's Sagem conducted an 11-day flight test

campaign to demonstrate the feasibility of operating its Patroller UAV in shared airspace. The platform underwent 20 tests during which an SAA FCS was utilised to test a collision-avoidance capability.

The SAA system, developed by Sagem and integrated in Patroller's control system, combines traffic detection sensors, including an EO/IR sensor and an automatic risk collision estimation and avoidance flightpath generation module. The company said it ran through various conflict scenarios with a 'dummy' aircraft provided by ENAC, enabling the Patroller to detect the risk of a collision and avoid it, without requiring an operator.

The platform also flew approaches to Toulouse-Blagnac airport according to procedures defined by air traffic control, demonstrating that a UAV is capable of operating in the terminal zone of an international airport without impacting traffic or safety.

■ PROOF OF CONCEPT

Meanwhile in the US, General Atomics Aeronautical Systems (GA-ASI), in collaboration with the FAA and Honeywell, has tested a proof-of-concept SAA system, marking the first successful test of the FAA's Airborne Collision Avoidance System for

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The SAA FCS fitted on Patroller underwent 20 avoidance test flights in October 2014. (Photo: Sagem)

Unmanned Aircraft (ACAS X U). The company also performed the first flight tests of a pre-production air-to-air radar for SAA called the Due Regard Radar (DRR).

In a statement issued in November, Frank Pace, president of aircraft systems at GA-ASI, said the SAA tests represented a major step forward in integrating RPA safely into domestic and international airspace.

'Our proof-of-concept SAA system is now functional and ready for extensive flight testing with the FAA, NASA and our industry partners,' he said.

GA-ASI's SAA system includes an automatic collision-avoidance and sensor fusion capability, designed to provide the operator on the ground with a clear picture of the traffic around the aircraft.

Three tests of ACAS X U took place in a Predator B during September 2014, where it was put up against other ADS-B and transponder-equipped aircraft.

The Predator made its own heading corrections, with an operator at a ground station sat ready to override ACAS X U in case it didn't work.

According to the company, this means that Predator B will be safe in the National Airspace System (NAS) 'in the unlikely event of a loss of the command and control data link'.

Work will continue to develop the ACAS X U aboard NASA's Predator B, called Ikhana. The platform will serve as the primary test aircraft in an SAA flight trial scheduled to take place in January at NASA's Armstrong Flight Research Center in Edwards, California. The flight test campaign will evaluate the SAA system across a variety of collision-avoidance and self-separation encounters and will include a sensor fusion algorithm being developed by Honeywell.

■ GETTING READY

Meanwhile, DRR testing has commenced on board a Beechcraft King Air in an attempt to detect and track multiple test aircraft across the full field of regard, including general aviation aircraft beyond 16km. The assessments are the first in an extensive flight test campaign designed to develop the engineering development model DRR fully and make it ready for flight testing on Predator B.

Elsewhere, US Navy Naval Air Systems Command (NAVAIR) is revisiting the SAA capability of the MQ-4C Triton HALE UAV. Triton will need global civil and military airspace access in addition to the US NAS, necessitating an effective SAA system on board.

With previous efforts failing to produce an SAA that met the required standard, NAVAIR is

now looking to industry to provide a solution. On 3 November, the Persistent Maritime Unmanned Aircraft Systems Program Office (PMA-262) issued an RfI calling for SAA solutions from industry, stating 'developmental efforts to date had failed to produce a design that meets performance and manufacturing requirements to successfully implement this critical technology'.

NAVAIR has determined to use a layered approach to the MQ-4C's SAA requirements, using both on- and off-board sensors to de-conflict with other air traffic. This would combine the transponder-based Traffic Collision Avoidance System with ADS-B to accurately plot the UAV's location and predict its intended flight path.

While neither approach meets the FAA's requirements for UAV SAA on its own, NAVAIR and the FAA are working with other international regulatory agencies to formulate a plan to use the systems in conjunction with one another.

The RfI states the SAA air-to-air radar system must be designed to fit within the defined SWaP constraints of the MQ-4C UAV and ➤

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Predator has an advanced flight control system but work is ongoing to make improvements for this and future platforms. (Photo: USAF)

that the system be modular and scalable for application in other type/model/series UAS.

'It must be capable of operating in a wide range of natural, induced and air traffic environments expected over the MQ-4C's life cycle, during all phases of flight,' the document states.

'Due to performance impacts associated with ground clutter, it is anticipated that an on-board air-to-air radar may require supplemental capability from ground-based

radars when operating in the terminal environment below certain altitudes. As such, SAA radar development growth provisions (spiral acquisition accomplished via an incremental approach) to address near-term operational needs, with future requirements/standards maturation within the civil and military aviation airspace, should be identified. A modular, scalable design, coupled with an incremental development approach is envisioned.'

MINIATURISATION MOVES

Miniaturising the SAA components to fit within the MQ-4C Triton has proven difficult, to the extent that Exelis, which was originally developing the SAA sensors under contract to Northrop Grumman, was issued with a stop-work order while the navy considers alternatives.

As other FCS continue to improve and shrink, capabilities normally associated with group four and five platforms like the MQ-1 Predator and MQ-9 Reaper are finding their way into smaller, more portable and easier to operate small UAS (SUAS).

In February, Lockheed Martin's Desert Hawk III SUAS demonstrated enhanced situation awareness capabilities as a result of the introduction of a new FCS. The company

commenced migrating its group 1 family of UAS to 'enhanced automation capabilities' using its Kestrel FCS and mobile Ground Control Station (mGCS) software in April 2014.

The company states that the latter substantially reduces operator workload through an intuitive interface, user-friendly touchscreen and joystick options, as well as a sophisticated set of operator warnings, cautions and advisories.

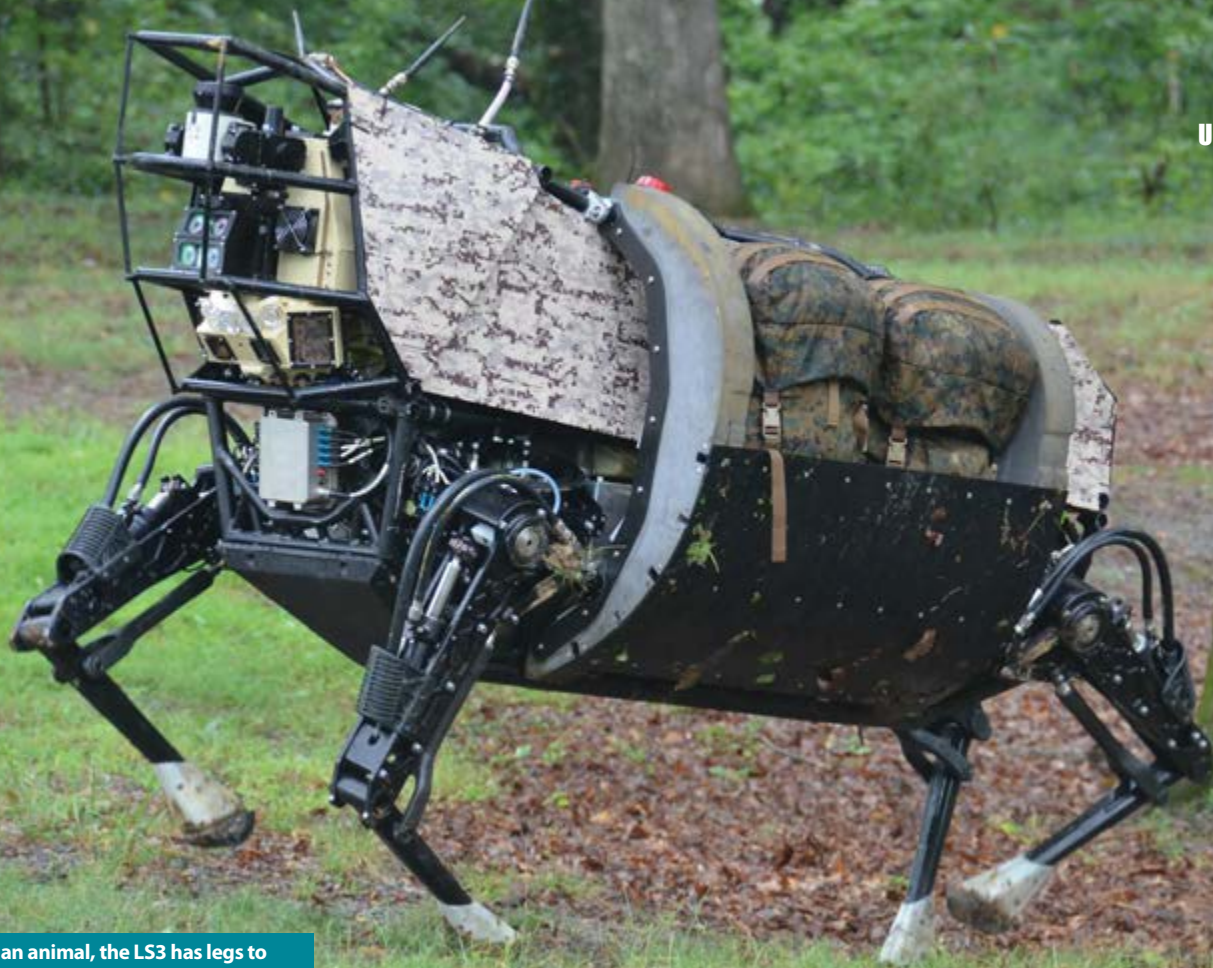
'The mGCS is a derivative of our proven VCS-4586 software that focuses on providing capabilities to the small unit level,' said Kevin Westfall, director of unmanned solutions at Lockheed Martin's Mission Systems and Training business.

'mGCS is a single, portable system capable of conducting missions that would typically require multiple controllers and federated software applications in order to manage the many different types of UAS.'

The mGCS was developed on an open system that is interoperable with a variety of portable computers, hand controllers, autopilots, data links and sensors. The software is compliant with NATO's STANAG 4586 and includes a full software development kit to provide other UAS manufacturers with the ability to add systems and other capabilities without restriction. **uv**



The Athena 411 weighs 1kg and contains gyros, an accelerometer, magnetometer, GPS receiver and air data pressure transducer. (Photo: Rockwell Collins)



Looking like an animal, the LS3 has legs to navigate difficult terrain that wheels or tracks can't cope with. (Photo: Boston Dynamics)

Cargo carriers

Interest in small UGVs that can meet the load-carrying needs of a single squad or small group of individuals is growing. **Scott R Gourley** looks at recent developments and the wider implications.

Soldiers possess the fitness levels to carry heavy loads, but what kind of capability could a squad have if the really hefty kit could be carried by a UGV? In the case of the US military, the recent interest in squad-sized load-carrying UGVs has been evidenced by their appearance at robotics rodeo events and warfighting experiments. Many of these platforms have drawn considerable interest from international military observers as well as those operating them.

It was at the US Army's third Robotics Rodeo, held in late June 2012 at Fort Benning, Georgia, where UGVs really started to capture the imagination. The event was hosted by a partnership between the US Army's Tank

Automotive Research, Development and Engineering Center (TARDEC), Joint IED Defeat Organization and the Army Capabilities Integration Center.

SHOWCASING SYSTEMS

As advertised by its sponsors, the event was designed to provide 'an opportunity for scientists and engineers from industry and academia to demonstrate new and innovative unmanned ground systems to the US Army user and R&D communities'. The idea was to demonstrate the spectrum of robotics capabilities, including deployment, set-up, protection, sustainment and relocation. The sustainment aspect was a particularly

interesting area – it required the participating UGVs to 'autonomously navigate to multiple designated locations and autonomously unload materiel in a specified order upon arrival'.

Later in October 2013, Fort Benning's Maneuver Center of Excellence hosted a robotics limited demonstration that further explored the potential of such platforms in both logistics and tactical applications.

One of the UGVs that participated was the Carry-all Modular Equipment Landrover (CaMEL) from Northrop Grumman. Powered by an electric drive system with six individual motors, it has hybrid power and can operate for 20 hours on 16l of fuel. ➤

According to Cap Cappelletti, Northrop Grumman programme manager for UGVs, CaMEL participated in both parts of the event: a 'lighten the load' load-carrying demonstration traversing the Squad-Multipurpose Equipment Transport; and a wireless live firing event.

'I want to say there were eight or nine different systems and out of those I think two or three of them participated in both parts,' Cappelletti said, adding that CaMEL's inherently modular design facilitated transition between the two roles.

'Early in CaMEL's development, conceptually what we wanted to do was keep our platform modular in design so we could adapt to multiple different missions,' he explained. 'We've done things with the CaMEL such as, obviously, lightening the load, but we are also exporting up to 2kW of power, which enables us to either recharge soldiers' batteries forward and/or run additional sensors. We've also done a communications retrans platform, network integration node and a [casualty evacuation (casevac) platform] capable of transporting wounded soldiers out of an environment. And we've also done a remote weapon system.'

CaMEL is loaded up with water, fuel, rations, rucksacks and ammunition crates.

(Photo: Northrop Grumman)



A K-Max picks up an SMSS to resupply a team of soldiers. (Photo: Lockheed Martin)

■ GAME CHANGER

He said that the early casevac concept featured two litters on CaMEL, but quickly added that the system's 450kg payload would 'obviously carry more wounded soldiers' and that the company would just need to design a different platform to make use of that additional payload.

'Again, it's kind of a game changer for us that we are exporting additional power,' he added. 'So if you think of a casualty victim, we can actually hook them up to some kind of heart monitor or IVs or anything that requires power – we're exporting that directly from the system itself. So not only are we transporting wounded, but there is the potential to run diagnostics while you are returning them.'

Cappelletti credited Phil Coker, director of Northrop Grumman's Integration and Engineering Center of Excellence, for CaMEL's early modular design emphasis, noting that the retired brigadier general 'understood early on that the more applications we would be able to demonstrate, the more beneficial the platform would become in a customer's eyes. So early, early on we wanted to keep this system relatively simplistic in use and modular in design to adapt to multiple missions.'

While the army was conducting its third Robotics Rodeo in 2012, it was also experimenting with load-carrying UGV platforms in combat. The service sent four Squad Mission Support Systems (SMSS) to Afghanistan for a five-month in-theatre assessment by and around soldiers, calling it Project Workhorse UGV. The 6x6 systems, developed by Lockheed Martin, have a gross vehicle weight of 1,950kg, a payload

capacity of 680kg and were used for all sorts: transporting kit to combat outposts; resupplying strongpoints; moving communications equipment around; carrying power units; battery charging; and even lugging fencing equipment and tools.

After Project Workhorse, SMSS subsequently participated in events like US government C-IED evaluations in September 2012 at Fort Leonard Wood, Missouri, as well as other service capability demonstrations.

■ SMSS DIRECTION

Myron Mills, SMSS programme manager at Lockheed Martin, explained where the project is currently at. 'During the past year, and particularly in the past six months, we did a couple of interesting and exciting things: one for the Army, which is sort of our traditional customer; and then another aimed at the first responder/fire-fighter market,' he said.

'At the end of summer 2014, we completed the demonstration for a programme that we had with TARDEC called Extending the Reach of the Warfighter through Robotics [ERWR]. In that programme, we teamed a "large" UGV – the SMSS – with a large UAV – the K-Max unmanned helicopter – and used that to complete a tactical resupply and reconnaissance mission down at Fort Benning.'

During this event, K-Max delivered the SMSS by sling load to a point where it was released to deliver supplies to a squad-sized unit protecting a village.

'It was the first time that we know of that basically squad-sized UGVs and UAVs were

used teamed with each other and in a manned-unmanned team to complete a combined arms air-ground type mission, all done beyond line of sight by autonomous and remote control,' continued Mills. 'So it was a pretty exciting event for us. It went very well and we're looking forward to some potential follow-on activity to that in the future.'

The second recent demonstration featured a company-funded variant of SMSS, dubbed 'Fire Ox', carrying and applying a wildland fire-fighting capabilities package.

MAN'S BEST FRIEND

Meanwhile, General Dynamics Land Systems has been working on its cleverly named Multi-Utility Tactical Transport, otherwise known as MUTT. The wheeled system, which can also be

equipped with tracks, has a 'tether' of nylon line that is attached to the soldier. Commands from the soldier to MUTT are translated through two sensors in the head of the tether. Dan Rodgers, programme manager for the system at General Dynamics, warned about some of the issues around using a UGV.

'If you give a soldier a tool to lighten his load or unburden him, it's not for free,' he cautioned. 'Usually there are all these complexities and burdens you add onto the soldier in terms of motor pool requirements, training requirements and interoperability mandates. There are all these things that go with it. We call them "UGV alibis" and we see MUTT as a "UGV alibi killer".'

Rodgers noted that a critical factor in MUTT's development has been the desire to provide

mobility as close to the dismount as possible. 'It was a very difficult challenge where we were shooting for 60-80% of what a dismounted soldier with an approach march load of more than 72lb – not an assault or fighting load – could do,' he said. 'The other thing about the design is to try to get as high of a payload fraction as possible.'

Rodgers was also keen to emphasise the multi-utility element. 'It really is multi-utility,' he stated. 'It's just a truck and like any other truck you can put all kinds of things on it. So the idea was to provide enough cube – meaning space claim – and expeditionary power so that they could pretty much hook up whatever they wanted to.'

Rodgers highlighted big successes in November at Fort Benning at the



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MUTT, featuring chunky tyres and a caged load area, is due to be put through more demo scenarios throughout 2015. (Photo: GDLS)

Manned/Unmanned teaming Limited Objective Experiment (LOE), where MUTT demonstrated the ability to deliver a .50cal machine gun on the battlefield.

'It currently takes five guys to get a .50cal downrange dismounted,' he said. 'But with MUTT, they can now carry a big weapon and a bunch of ammo, so you get much more firepower forward.'

GIVE A MUTT A PHONE

Another example is the carrying of the communications relay package for a counter-IED type of protection bubble. Rodgers explained: 'Both of those things provide protection when they are mounted on tactical vehicles, but dismounts don't have that protection. So what they want to be able to do is not lose communications back to higher command and they still want the protection, for example of the [counter-IED] bubble. We provide a truck that can carry existing equipment and allows them to do that.'

The past 12 months have seen the MUTT design evolve from a 'beta' to a 'gamma' configuration, with demonstrations for the US Army at Fort Benning, Fort Leonard Wood and Fort Bragg, as well as the USMC. Additionally, Rodgers said that the system was also 'put in

front of some foreign militaries, including the Belgians and Canadians'.

'It's been a year of touring and exposing it to different people,' he added. 'We listened to their feedback and made improvements throughout the year. I think the general impression was that when people see it, there is an immediate kind of appeal to it – on both personal and professional levels.'

Then they would say, 'Here's what I want to do with it,' or 'Here are some perceived limitations – can you change that?' So we went through a series of those demonstrations, upgrades and evaluations that culminated in the MUMT LOE.'

LEGGY SUPPORT

Another load-carrying UGV participating in some demonstrations is the Legged Squad Support System (LS3), developed by Boston Dynamics with funding from DARPA and the USMC.

The four-legged LS3 is a rough-terrain robot designed to go anywhere marines and soldiers go on foot, helping carry their load. Each system weighs approximately 590kg, including 180kg of gear and enough fuel for a 32km mission lasting 24 hours. LS3 automatically follows its leader using computer vision, so it does not



REX, another UGV with a dog-related name, is effectively a platform that can be loaded up with kit for soldiers. (Photo: IAI)

need a dedicated driver. It also travels to designated locations using terrain sensing and GPS.

Load-carrying UGVs aren't just being developed in the US. In March 2012, Israeli company IAI unveiled REX Field Porter, a small four-wheel robotic platform weighing approximately 200kg that autonomously accompanies units of three to ten soldiers and is capable of carrying approximately 250kg of equipment and supplies.

The REX design features a 'jackets' concept to reconfigure the vehicle for missions like logistics or intelligence support.

Some other load-carrying UGV designs that have emerged over the past few years include the Professional Robot, which developer Roboteam describes as 'the only tactical logistic platform for indoor and outdoor operations'. The system weighs just over 225kg (including carriage) but has the ability to transport 250kg of load.

WIDER APPLICATIONS

Looking out over the next 12 months, several industry representatives pointed to additional demonstration processes against a possible background of expanding international interest and continuing design evolution.

Northrop Grumman's Cappelletti, for example, pointed to the end of 2014 as a time of traction, with possible FMS for CaMEL. 'We were actually talking with Singapore about leasing some of our demo systems for them to put real-world environments and then get back to us on the requirements they wanted the system to do,' he explained.

'Then we were going to build a few. But unfortunately we lost traction with that. At the same time we were working with Brazilian fire-fighters who were interested in an autonomous platform to help fight brushfires, and also talking with the IDF. They were specifically looking for logistics systems and were a lot like Singapore in that they wanted us to send them something now that they could use in the field and then get back with their specific needs.'

Describing the current CaMEL design as 'a baseline,' he noted that US Army system requirements have been somewhat fluid over the past few years.

'We've been pursuing this effort since 2011 and while requirements do come out, they are constantly changing,' he said. 'And it depends on what army organisation you talk to. They all want just a little bit different capabilities from the system and we could absolutely drive our folks crazy trying to engineer a system to accomplish all of this.'

'So we were tasked with baselining a complete system that was very reliable, hardened and able to adapt to multiple missions – and just kind of sit on that for a while. What we truly need is for a customer to come out and say that they are willing to commit some money for this and here are the specific things we want your system to do. That's what we're waiting for.'

NEXT MOVES

Likewise, Mills indicated that the SMSS team was also watching to see what the army's next move is going to be and, more importantly when.

'There is some interest and some potential programme on the horizon,' he noted. The Defense Mobility Enterprise recently released their annual plan and that has a high-level

roadmap, if you will, of the various S&T-type programmes that they would like to pursue.

'There are quite a number of programmes of interest to us in there. We're taking a hard look at them and certainly we're hoping that we can be successful at winning some of that business in the coming 12 months. So there is actually activity out there in the S&T community for robotics, but it's something that we're going to have to work on and go compete for.'

He continued: 'During 2015, I think the army is still working hard to kind of finalise their plans and figure out how they're going to move out with unmanned systems in the future. And we're just going to try to support them every way that we can to be there when they need us as they move forward.'

CRUCIAL CELLS

Meanwhile, Rodgers predicted that this year would see both continued design refinements and demonstrations for MUTT. Acknowledging there are still some things the company needs to do, he said: 'We need to get the fuel cell so that it had the legs in there. The tracked variant was a huge hit. It does everything mobility-wise, which is important. So we intend to do a similar thing this year with internal funding married with sponsored experiments and utility assessments.'

Some additional development work may refine a temporary remote-control capability that would be important in environments like streambed crossings. This could also be used for a 'breaching configuration' of MUTT, where the robotic platform could be sent forward alone to perform the tactical breach.

PLANNED SCHEDULE

In addition, Rodgers said that he expects several demonstrations in 2015. He pointed to additional evaluations in various configurations, for unique groups of people and in new environments.

'The schedule is filling up,' he said. 'We have continued demonstrations planned all the way through the fall. What we've heard from TARDEC is that they've already got us going up to Alaska [for cold-weather testing] and they're talking about the 25th ID [in Hawaii], Fort Bragg and also doing something at Fort Leonard Wood with the combat engineers – all based on the MUTT, because of its inherent capabilities.'

'Right now there are a lot of "requirement writer types" who think that the MUTT, as a capability, is the way to go. Now, that's not necessarily "our MUTT", although we like to think that ours is kind of setting the tone. But it's that capability and utility of it.' **uv**

Payload fractions

In his discussion of MUTT design philosophies, Rodgers cited a goal of 'as high of a "payload fraction" as possible.'

That concept of payload fractions is one criteria for measuring load-carrying systems. Specifically, it refers to the amount of capacity in comparison to the weight of the carrying system. A ratio of 1:1 would equate to a 50% payload fraction.

Rodgers offered a conceptual example of individual load-bearing equipment (LBE), where approximately 8kg of LBE are able to carry up to 68kg of equipment, noting, 'That's close to an 85% payload fraction, which is very high.'

In terms of vehicular platforms, he highlighted the ubiquitous HMMWV, which he characterised as having 'a great payload fraction of almost 1:1.'

Acknowledging that the MUTT design falls short of the 50% target set by developers, he said that it is still impressive in an arena where some other load-carrying UGVs have fractions that are much lower.

*Moreover, some of these robotic military platforms are also being seen for load-carrying applications outside of the defence arena. **uv***

Watching brief

With the British Army's Watchkeeper now in service, Angus Batey speaks to **Matt Moore**, global product line manager for UAS at Thales, about the present and future of the programme.

When the British Army's Watchkeeper made its belated entry into service late last year, media reactions were less than ecstatic. The programme appeared to have been dogged by delays and the brief deployment – on the eve of British forces withdrawing from Afghanistan altogether – looked to provide a poor return on the MoD's long-term investment. But those who have seen Watchkeeper through that particular drinking straw have missed the wider area view.

WIDER VIEWS

Moore has seen the programme from every possible angle. During a 16-year career in the British Army, the majority of it spent in ISR, he served as UAV commander during Operation Herrick in 2008, where he was responsible for platforms including the Watchkeeper's predecessor, the leased Hermes 450. He then took over as senior officer in charge of the development of UAS capability at HQ Army and joined Thales in January 2012.

'People think Watchkeeper looks similar to Hermes, but it's a very different aircraft,' he said. 'It's been designed for all-weather, high-intensity warfighting environments, but also has the ability to do traditional surveillance tasks. Taking Watchkeeper to Afghanistan met a critical requirement, an ISR gap the army had at that time. Words like "outstanding" and "force multiplier" were used, which was excellent news for us.'

'The key differentiator between Watchkeeper and Hermes 450 is the Thales I-Master radar,' he continued. 'That brought a new dimension to the battlefield. Linking that with the EO payload gave a very capable wide-area surveillance, and an all-weather capability

to enable pinpoint accuracy in reporting what was going on.'

RAMPING UP

With the hardware now almost all in the hands of the customer, work is ramping up on enhancing the system's capability and expanding its utility to the MoD.

'I've got an aircraft and other equipment being delivered as we speak. But the majority of the operational stock has been delivered.'

'We're about to start delivering the second batch of enhanced capability. You'll see things like de-icing and multi-air vehicle control coming into the capability format and footprint. Last year, we released our maritime moving-target indication mode on I-Master and we're in conversation with the Royal Navy now on how to maximise the system for the littoral and maritime environments.'

He continued: 'Currently Watchkeeper is an imagery platform, but we're also looking at other new payloads to turn the system into a multi-sensor, multi-mission platform as well. And new technologies, be it COMINT, radar ESM, other types of hyperspectral payloads or other electronic surveillance capabilities, will be introduced.'

A key part of the original MoD requirement – and part of the reason for the delays in fielding the system – was the need for Watchkeeper to be able to fly outside military airspace. The precise nature of how that could be achieved changed during the programme's gestation.

'Within UAVs and certification and airspace, and aviation within the military generally, there was that strategic shock of [Charles] Haddon-Cave's report [in 2009],' Moore recalled. 'Of course, the Watchkeeper



programme had to adapt to accommodate those recommendations. Watchkeeper's high level of certification is a first for a type of this size. That's an absolute game-changer – it's part of the evolution of UAVs in the future, and part of the evolution of flight.'

ON THE HORIZON

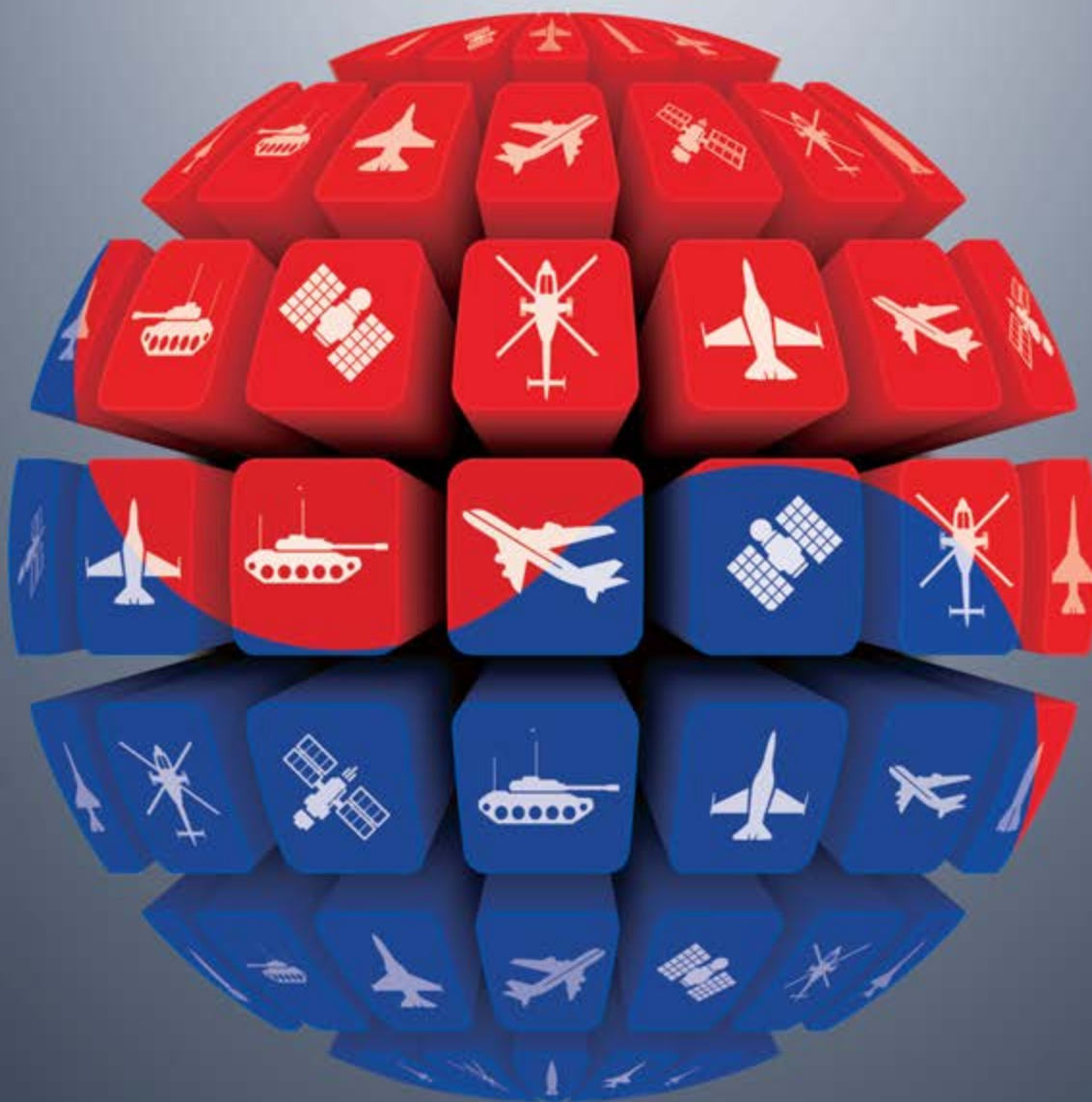
Further expansion of the system's legal and technical capability to carry out flights in non-military airspace is also on the horizon.

Thales has been an important contributor to the ASTRAEA consortium's efforts to solve the problems preventing access to civil airspace for BLOS UAS, and is involved in the CLAIRE project (see p14), which later this year will see a Watchkeeper fly in unsegregated airspace in the UK for the first time. Other technical developments are in the pipeline, leading to the goal of readying the platform for further sales to military and non-military customers.

'We have a sense-and-avoid programme working at the moment, optical and radar-based, to ensure we maximise the ability to put our UAVs into that airspace safely. Watchkeeper is ideally positioned, with its certification standard and safety case, as a complete system to help support integration projects and start developing the ability to move into unsegregated or controlled airspace. If we start working in a civil environment as well there's maximum benefit and business opportunities in the long term.' **uv**

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